I. C. 7499 MAY 1949

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

REOPENING AND DEVELOPING A SMALL RED-IRON-ORE MINE GADSDEN, ALA.

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REOPENING AND DEVELOPING A SMALL RED-IRON-ORE MINE, GADSDEN, ALA.[1]

By John C. Feeley, Jr.[2]

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2/ Mining engineer, Bureau of Mines, U. S. Department of the Interior.

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INTRODUCTION

The methods used and the funds available for the development and operation of small mines and the reopening of small abandoned mines frequently present problems that tax the ingenuity and resourcefulness of the mining engineer far beyond that required in the mass production from large deposits. The objective of this paper is to describe in considerable detail the means whereby engineers have solved local problems in reopening an abandoned mine at which equipment, facilities, and funds were limited.

The Etowah Coal & Iron Co. Gadsden red-iron-ore mine at Gadsden, Ala., is of interest in this category since it is the only independent red-ore mine under active development in the State. All other red-ore mines in Alabama are owned or controlled by the large iron or steel companies.

The mine, located on the southwest end of Shinbone Ridge in the outskirts of Gadsden lies in an area once productive but now idle for many years. The ore is relatively highgrade compared with that in the Birmingham area, but the bed is thin and somewhat lenticular. The presence of a large blast furnace at Alabama City, 5 miles from Gadsden, and the growing scarcity of red-iron ore supplies for it offered inducements for reopening the mine in 1946.

Up to the time this circular was prepared (1947) only a small quantity of ore (about 1,500 tons) has been produced and shipped to the furnace.

A force of 14 men was employed in sinking the main slope and developing a third "lift" (a local term for level) 100 feet below the old mine workings.

ACKNOWLEDGMENTS

The Bureau of Mines, through its Mining Division; Lowell B. Moon, chief, has as its primary objective the more effective utilization of domestic mineral resources. It recognizes the value of dissemination of pertinent information relative to the technical development of small mines and the rehabilitation of abandoned mines as a help to the engineer operating with limited resources in the solution of his problems.

This report was prepared under the immediate supervision of J. R. Thoenen, chief, Tuscaloosa Branch, Mining Division.

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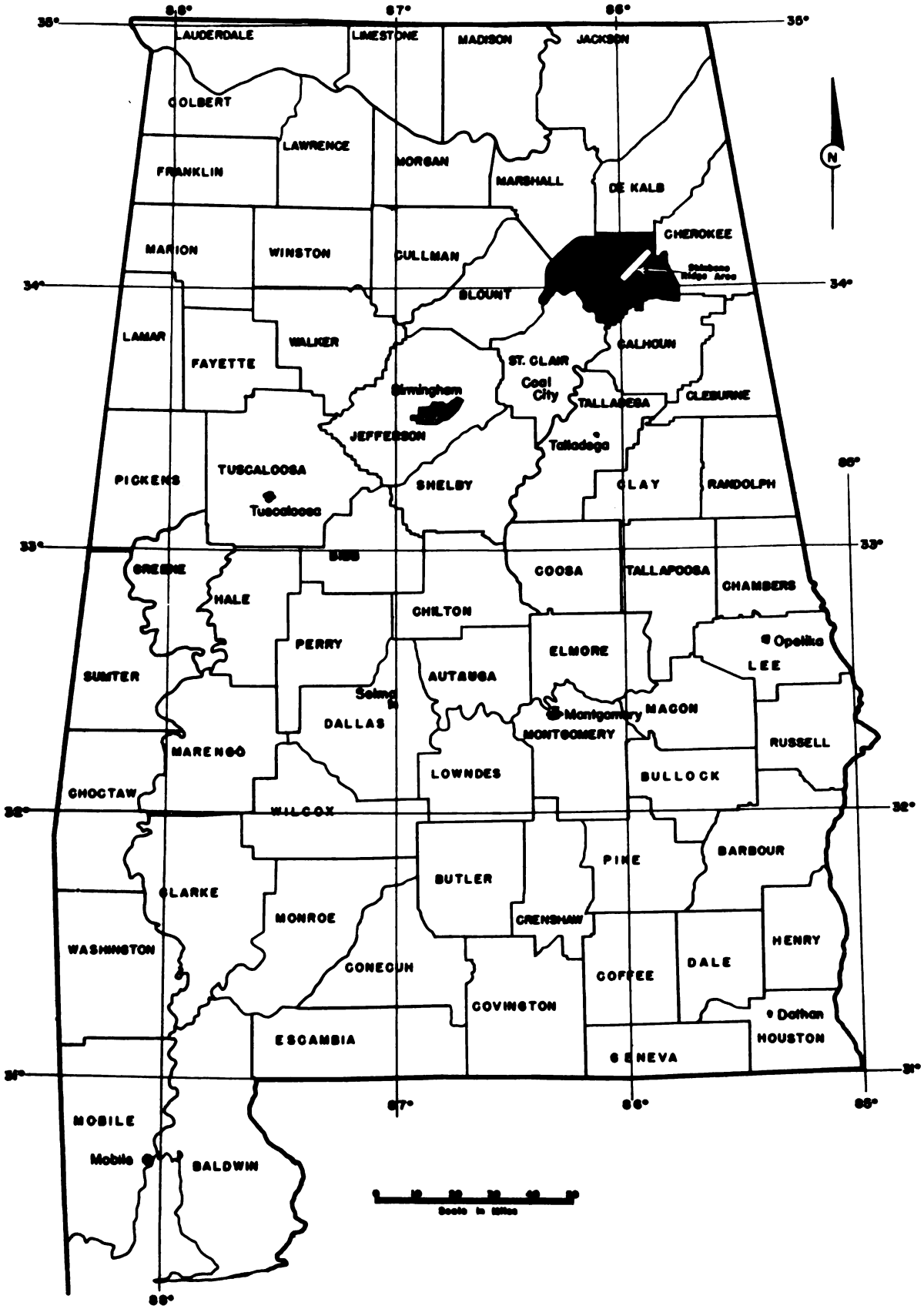

Figure 1. - Index map, State of Alabama.

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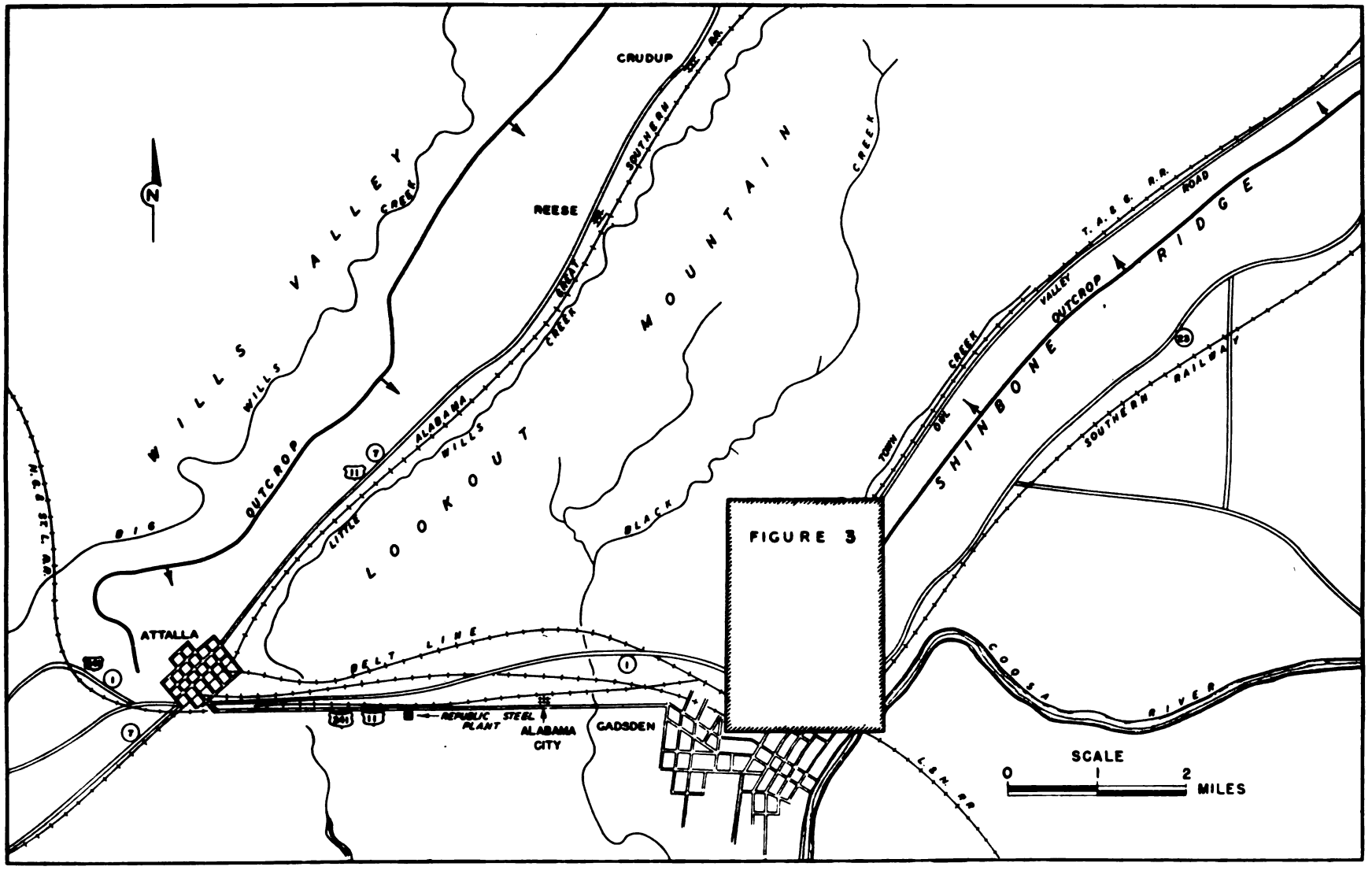

Figure 2. - Map showing Gadsden area, Etowah County, Ala.

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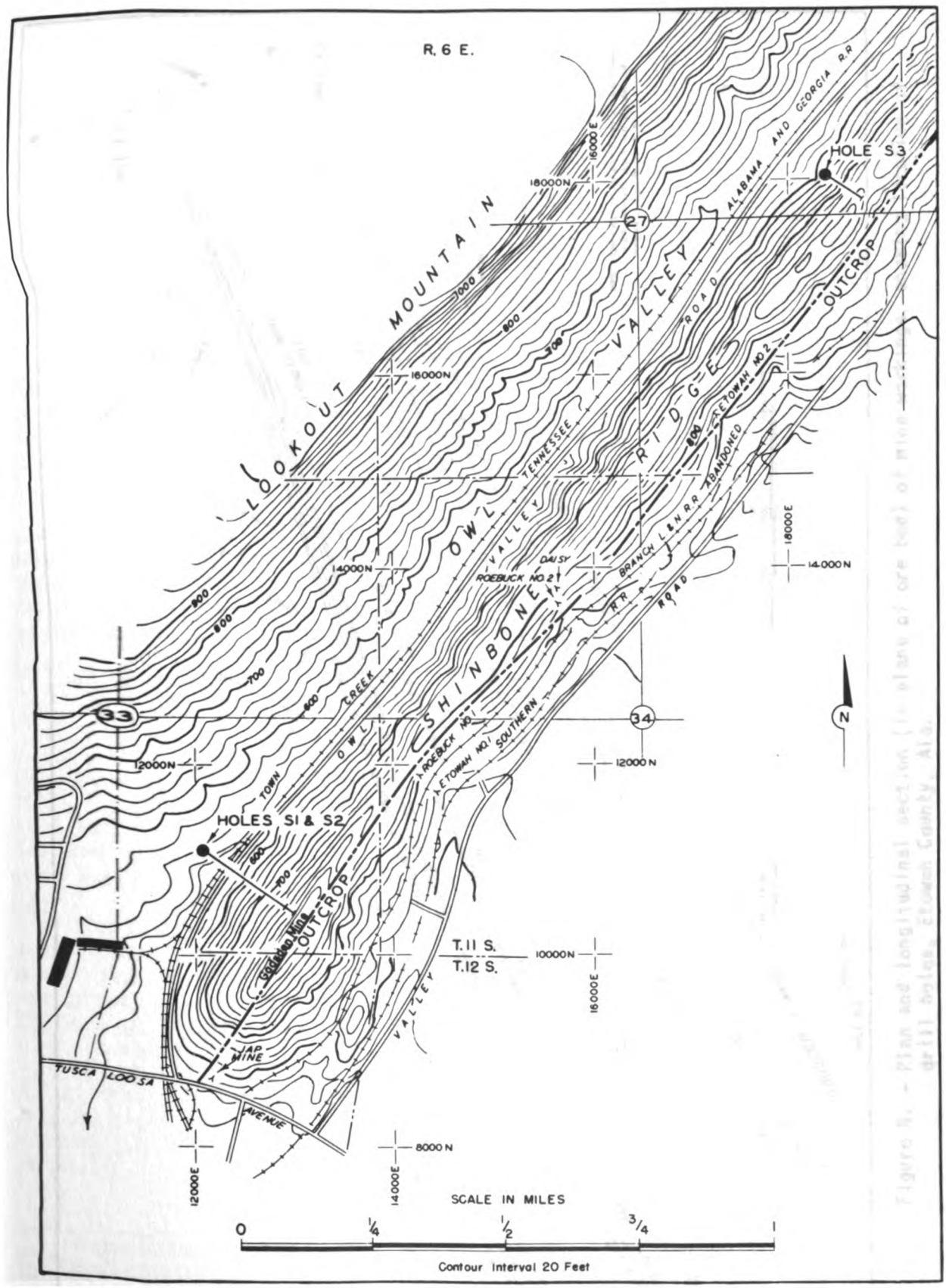

Figure 3. - Map showing location of mines and drill holes along Shinbone Ridge, Etowah County, Ala.

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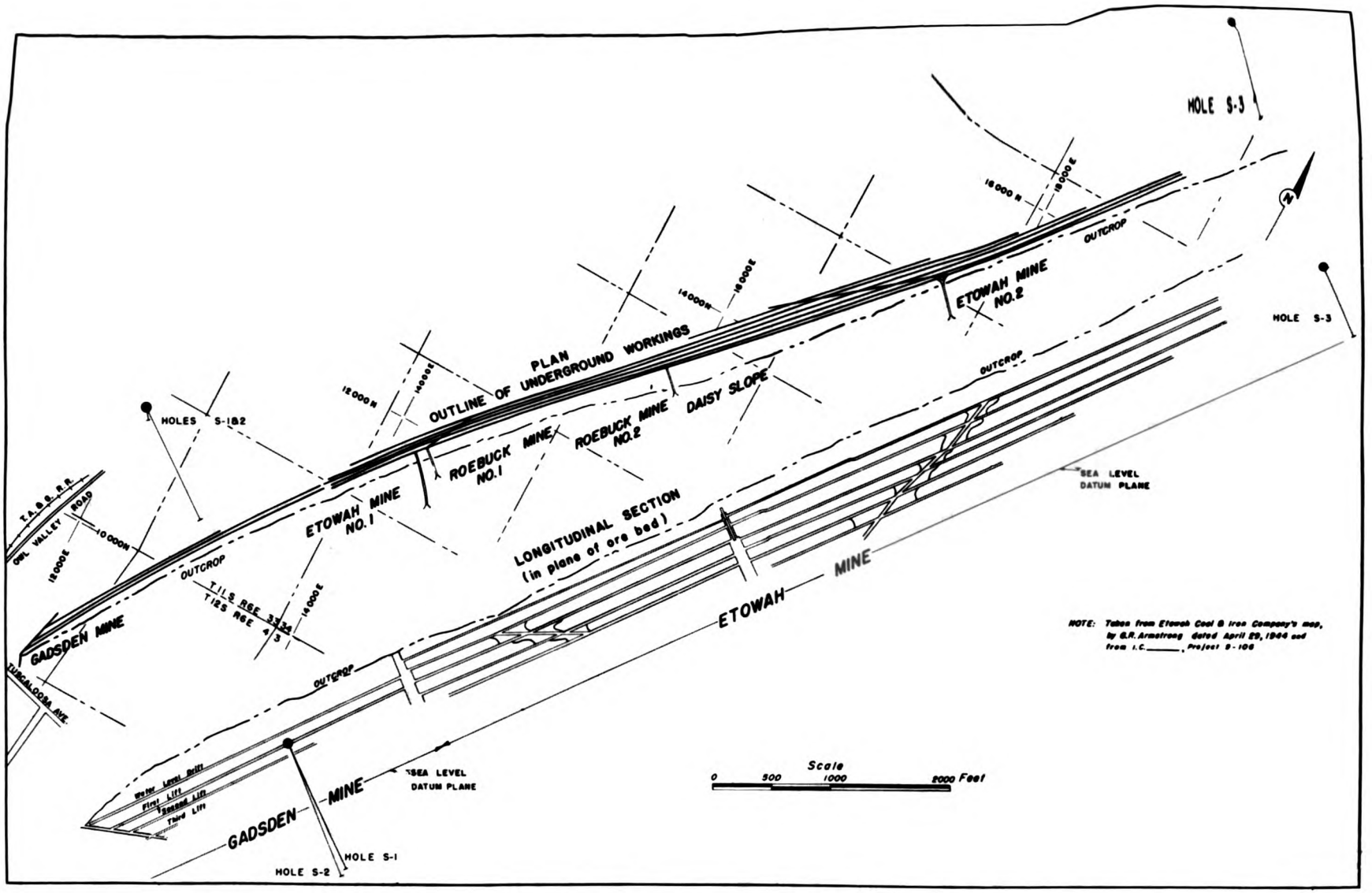

Figure 4. - Plan and longitudinal section (in plane of ore bed) of mine workings, showing location of drill holes, Etowah County, Ala.

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Thanks are given for the cooperation and assistance of A. Page Sloss, president, and G. R. Armstrong, vice-president, of the Etowah Coal & Iron Co., without which this report could not have been written.

LOCATION AND ACCESSIBILITY

The Gadsden mine is in the southwest end of Shinbone Ridge, sec. 33, T. 11 S., R. 6 E., and sec. 4, T. 12 S., R. 6 E., Etowah County, Ala. (figs. 1, 2, and 3). The surface plant and mine slope portal lie within the corporate limits of Gadsden, a city of about 40,000 population. The mine office is at 574 Tuscaloosa Avenue at the southwest terminus of the ridge.

Gadsden, the county seat of Etowah County, situated on the northwestern side of the Coosa River Valley, is about 55 miles northeast of Birmingham, the principal source of mining equipment and supplies. A blast furnace of the Republic Steel Corp. is at Alabama City (recently incorporated within the city limits of Gadsden), about 3 miles west of Gadsden.

Birmingham, Attalla, Alabama City, and Gadsden are connected by the Alabama Great Southern and Louisville & Nashville Railroads and by U.S. Highway No. 11. The Tennessee, Alabama & Georgia Railway extends from Gadsden, the southern terminus, through northwest Georgia to Chattanooga, Tennessee. The Nashville, Chattanooga & St. Louis Railway has a branch line from Attalla to Gadsden.

Electric power is supplied by the Alabama Power Co.

HISTORY

Red iron ore is believed to have been discovered in Shinbone Ridge before 1850.[3] From about 1900 through 1912, what is now the Gadsden mine was operated by a man named Hammond and often is referred to as the Hammond mine.[3] Ore was shipped to the Standard Steel Co. and to the Gulf States Steel Corp. (now Republic Steel Corp.) at Alabama City.

During World War I the mine was operated by a Japanese company, a subsidiary of the Mitsui Co. of Japan. This company also operated small coal mines in the vicinity of Coal City, St. Clair County, where beehive-oven coke was produced. A small blast furnace was operated in the vicinity of Talladega, Talladega County (fig. 1). The company exploited the ore bed through a horizontal distance of about 2,800 feet northeast from the portal of the main 33° slope and down to the second lift, about 200 feet below the water level (fig. 4). Ore was sent to the Talladega furnace, where pig iron was produced and shipped to Japan. After the close of the war, the entire operation was closed in 1919. This operation explains the origin of the local name, "Jap" mine.[4]

3/ Armstrong, G. R., vice president, Etowah Coal & Iron Co.
4/ See footnote 3.

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Following abandonment of operations by the Japanese company, the iron and coal mines mentioned were conveyed to the Wattsville Coal & Iron Co., from which control was acquired by the Etowah Coal & Iron Co.

There are no records showing operation of the Gadsden mine from 1919 to 1946, when the present work of unwatering, rehabilitation, and development was begun.

Blast furnaces have been operated in the Gadsden area, with periods of inactivity, from 1883 to 1926. The Quinn Foundry Co. operated a furnace from 1883 to 1907; it was dismantled in 1911. The Alabama Consolidated Coal & Iron Co. operated two furnaces from about 1899 to 1913. In 1924 these furnaces were acquired by the Sloss-Sheffield Steel & Iron Co. and operated until 1926 in conjunction with the company Etowah mine, adjoining the Gadsden mine to the northeast in Shinbone Ridge and mines in the Attalla area. The furnaces were dismantled in 1935.2/

Iron ore for the Gadsden blast furnaces was also supplied by other small mines in northeastern Alabama.

GEOGRAPHY AND CLIMATE

The topography ranges from the gentle sloping Coosa River Valley to the moderate foothill relief of Shinbone Ridge. The elevation above sea level is about 500 feet in the vicinity of Gadsden and rises to about 750 feet on the crest of Shinbone Ridge, along which the mines are located.

Shinbone Ridge is an elongated ridge, formed along the more erosion-resistant, upturned rock formations, and trends northeast from its southwest terminus at Gadsden. It is southeast of and parallel to Lookout Mountain, from which it is separated by Owl Valley, averaging not over one-half mile in width. The northwest side of Owl Valley is steep and precipitous in places.

The lower half of Shinbone Ridge is covered by a thick growth of underbrush and scattered pine trees. The upper half of the ridge supports a forest of good mine timber.

The climate is favorable for year-round mine operation. The average yearly rainfall is about 55 inches, which is distributed throughout the year. March usually covers the period of greatest rainfall, and September is referred to as the dry month of the year. The mean average temperature is reported by inhabitants to be about 43° F. for winter and about 80° F. for summer. The maximum temperature for summer is about 100° F., and subfreezing winter temperatures usually last only a few days. The spring and fall months are accompanied by moderate temperature ranges and are considered ideal for outside work and recreation.

2/ Woodward Iron Co., Woodward, Ala., Alabama Blast Furnaces: 1940, pp. 68-69, 71-72.

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The principal industries around Gadsden are farming, manufacturing rubber tires and textiles, and the production of iron and steel at Alabama City. The Alabama Power Co. is building one of its large, coal-burning, steam-electric, power plants at Gadsden.

GEOLOGY

According to Burchard and Andrews,[6]

> Northeast Alabama in the Cumberland Plateau region west of the Coosa River is underlain by Paleozoic sedimentary rocks ranging in age from Cambrian to Carboniferous (Pottsville). The plateau has been incised by several streams forming valleys which trend northeast-southwest following the axes of narrow folds..... The Red Mountain formation, formerly termed the "Clinton" and the "Rockwood" formation by the Federal and certain State Geological Surveys, is composed chiefly of sandstone and shale with beds of hematite, or iron ore.....
>
> The iron-bearing zone is usually found near the middle of the Red Mountain formation, which in northeast Alabama ranges generally from about 500 to 700 feet in thickness. One to four beds of iron ore are present at various places. It is seldom that no iron ore is found except where part of the formation is faulted out of the section.....
>
> ..... The total length of outcrop of Red Mountain formation along Shinbone Ridge in Alabama is more than 40 miles.
>
> The rocks that form Shinbone Ridge are, in their normal ascending sequence, the Chickamauga limestone which lies along the southeastern base of the ridge, the shale, sandstone, and ferruginous beds of the Red Mountain formation which form the southeastern slope and extend nearly to or beyond the crest, the black Chattanooga shale, the Tuscumbia limestone and Fort Payne chert which lie on the northwest slope. The Hartselle sandstone and the Bangor limestone form the northwest base of the ridge and the floor of the valley between the ridge and Lookout Mountain.....
>
> A geological section across Shinbone Ridge, Lookout Mountain and Red Mountain a few miles northeast of Gadsden and Attalla would show the ore-bearing beds of the Red Mountain formation presumably extending from their outcrop in Shinbone Ridge beneath Owl Valley, Lookout Mountain and Little Wills Valley to come to the surface in Red Mountain, thus forming a broad synclinal basin rather sharply upturned and probably more or less faulted in or below Shinbone Ridge, on the southeast edge.....

6/ Burchard, Ernest F., and Andrews, Thomas G., Iron Ore Outcrops of the Red Mountain Formation in Northeast Alabama: Geol. Survey of Alabama, Spec. Rept. 19, 1947, pp. 1, 206-208.

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> Beginning at the east-west fault at Gadsden and extending northeastward, the ore bed of the Red Mountain formation that crops out in Shinbone Ridge shows a variable but progressive deterioration in both thickness and quality. Near Gadsden the ore is 2-1/2 to 4 feet thick, but within 2-1/2 miles it thins locally to 1 foot 8 inches. Near Gadsden the dip is steep to the northwest. Between 5 and 8 miles from Gadsden, in the vicinity of the Citico mines, the thickness of the ore ranges between 2 and 3 feet and the dip is less steep, ranging from 30° to 40° NW.....

The ore beds along Shinbone Ridge bear about N. 30° E. for about 4 miles from Gadsden, thence change to about N. 50° E. Since the ridge comprises the sharply upturned southeastern limb of a syncline, the beds dip steeply (78° to 80°) to the northwest in the Gadsden and adjoining Etowah mines. The dip gradually diminishes with increased depth (fig. 5).

The ore bed varies from 2.5 to 4 feet in thickness. The company estimates an average of 3.5 feet of minable ore. The immediate hanging-wall formation is a medium-hard, dark shale, and the foot-wall formation is a medium-hard, gray sandstone.

The types of red ore occurrences are: Dense fine-grained hematite, oolitic hematite, and fossiliferous hematite. These variations grade from one to another across the ore bed and along its lateral and vertical extensions.

The section of the iron-ore bed lying next to the hanging-wall shale is siliceous and is classified as hard ore. In places, along the hanging-wall section, shale lenses are enclosed in the hematite beds. The foot-wall section embraces the more uniform and higher grade ore.

The lime content of the ore has been reduced by leaching action along the outcrop; consequently, it is soft ore and contains a higher percentage of iron than deeper ore mined underground. Most of the outcrop has been scalp-mined to a depth of 8 to 10 feet or more.

Cores from Bureau of Mines diamond-drill holes S-1 and S-2 disclose two red hematite beds shown in the vertical cross section (fig. 5). The two beds are separated 3-1/2 to 4 feet by shaly sandstone. Only the hanging-wall bed has been mined.

PHYSICAL CHARACTERISTICS OF ORE AND ENCLOSING ROCKS

The red hematite ore bed is a medium-hard rock and stands unsupported in mine openings and stopes.

The dark shale hanging-wall formation ranges from 3 to about 50 feet or more in thickness and is also a medium-hard rock. It is firm enough to stand in mine slopes, drifts, and crosscuts without the aid of timber. It is also firm enough to provide for shrinkage stoping, without excessive dilution of broken ore, provided the broken ore is kept close to the back, and heavy shooting against the hanging wall is avoided while stoping is in progress.

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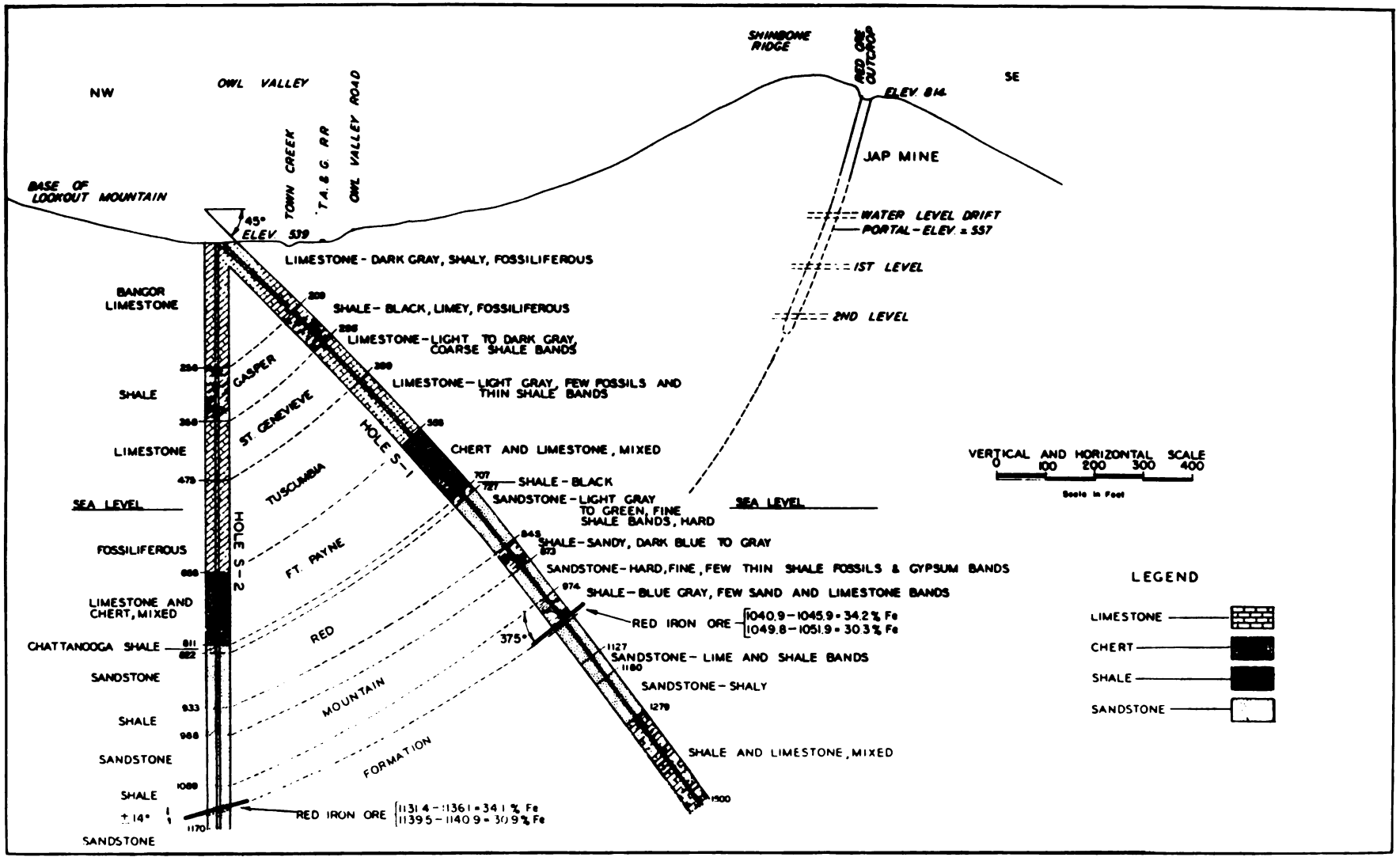

Figure 5. - Vertical section through drill holes S-1 and S-2 and Gadsden mine, Etowah County, Ala.

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The sandstone foot-wall formation, a medium-hard to hard rock, is dense and tough.

The dip of the ore bed, 75° to 80°, also permits shrinkage - stoping methods. However, the dip gradually decreases with increased depth (fig. 5), and shrinkage stoping will be limited to some depth where caving of the hanging-wall shale dilutes the broken ore beyond the limits of profitable mining or to a depth where the dip becomes too flat for shrinkage methods.

There are no known structural irregularities, such as faults and fracture zones, to offset or otherwise interrupt and deform the ore bed in its normal downward extension. An east-west fault is reported by Burchard[7] to delimit the extension of the ore bed southwest of Tuscaloosa Avenue in Gadsden.

Information on the grade of ore mined and shipped, by previous operators, is meager. According to Burchard,[8]

Analyses of ore produced in 1910-1912 from Hammond and Etowah mines are as follows:

Analyses of iron ore from Hammond and Etowah mines

Mine	Fe	SiO_2	Al_2O_3	CaO	Mn	P	H_2O
Hammond	37.54	11.19	5.38	14.51	0.11	0.37	1.80
Hammond	36.94	12.82	5.41	13.44	-	-	.90
Hammond	40.35	9.20	4.82	12.58	-	.44	1.00
Hammond	36.14	11.89	4.88	14.03	-	.50	-
Hammond	32.02	18.80	8.04	18.88	-	-	-
Etowah	41.67	6.92	3.49	14.99	-	-	-

Armstrong[9] believes that the high percentages of silica in the foregoing analyses of ore shipped from the Hammond mine were due to failure to sort out and discard shale from the broken mine ore before it was shipped to the blast furnace.

An average analysis of small shipments of ore from present development is: Fe 40.70 percent, insoluble 11.64 percent, P 0.45 percent, Mn 0.14 percent, and CaO 12.28 percent.[10]

An average analysis of ore shipped from Sloss-Sheffield Steel and Iron Company's Etowah ore mine for the last two years of operation, 1924-1926, is: Fe 41.48 percent, SiO_2 8.20 percent, Al_2O_3 4.10 percent, $CaCO_3$ 17.89 percent and P 0.44 percent.[11]

7/ Work cited in footnote 6, p. 211.
8/ See footnote 7.
9/ Armstrong, 9.R., vice president, Etowah Coal & Iron Co.
10/ See footnote 9.
11/ See footnote 9.

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SURFACE TRANSPORTATION

Tusaloosa Avenue, Gadsden, provides a roadway for truck and automobile service. A spur track of the Louisville & Nashville Railroad passes between the hoist house and railroad ore bin and extends across Tuscaloosa Avenue, thence along the western limit of the mine dump.

The company owns no trucks. Truck transportation, including hauling waste rock from the mine bin to dumps, is contracted to local truck owners.

WATER SUPPLY

Surface water is plentiful in the vicinity of Gadsden, and in addition the mine has developed a minimum flow of about 60 gallons a minute. Fresh water for the mine, surface plant, and domestic use is supplied from the water system of the City of Gadsden at a rate of $25 to $30 monthly.

CAMP

An official residence, mine office, and change house are the only buildings owned and maintained by the company for use of its employees. Labor employees live in and around Gadsden.

Sewage disposal is handled through the city's sewage system.

SURFACE PLANT

The surface plant (figs. 6, 7, and 8) embraces the following: Official residence, mine office, change house, blacksmith shop, compressor house, hoist house, mine cable tower, head frame and mine bin, feeder plate, picking-belt conveyor and crusher, ore-belt conveyor, railroad ore bin, water pipe lines, and electric transformers and power lines. The arrangement of the plant is shown in figure 6.

Since the costs of construction labor, engineering, supervision, freight, most material, and part of the equipment were not available in detail, it was necessary to estimate and use comparative costs and prices to estimate the detailed cost of the surface plant. All lumber estimates used throughout this paper provide for a 10-percent cutting and framing loss.

A description of the surface plant and buildings follows.

Official Residence

The official residence (fig. 9) is a 24- by 28-foot, four-room, single-story frame house, on an 8-inch brick wall, with a 1/4-pitch gable roof. Studs, rafters, joists and wall plates are 2- by 6-inch pine lumber. Floors are double-rough boards below with matched pine flooring above and paper between. Outside walls are sheathed and the roof decked with 1-inch pine lumber covered with building paper. The walls are sided with asbestos shingles, and the roof is covered with corrugated sheet aluminum. Interior walls and ceilings are lined with wallboard and plastered. The bath and kitchen are supplied with modern plumbing, and the house is wired for electric cooking, heating, refrigerating and lighting attachments.

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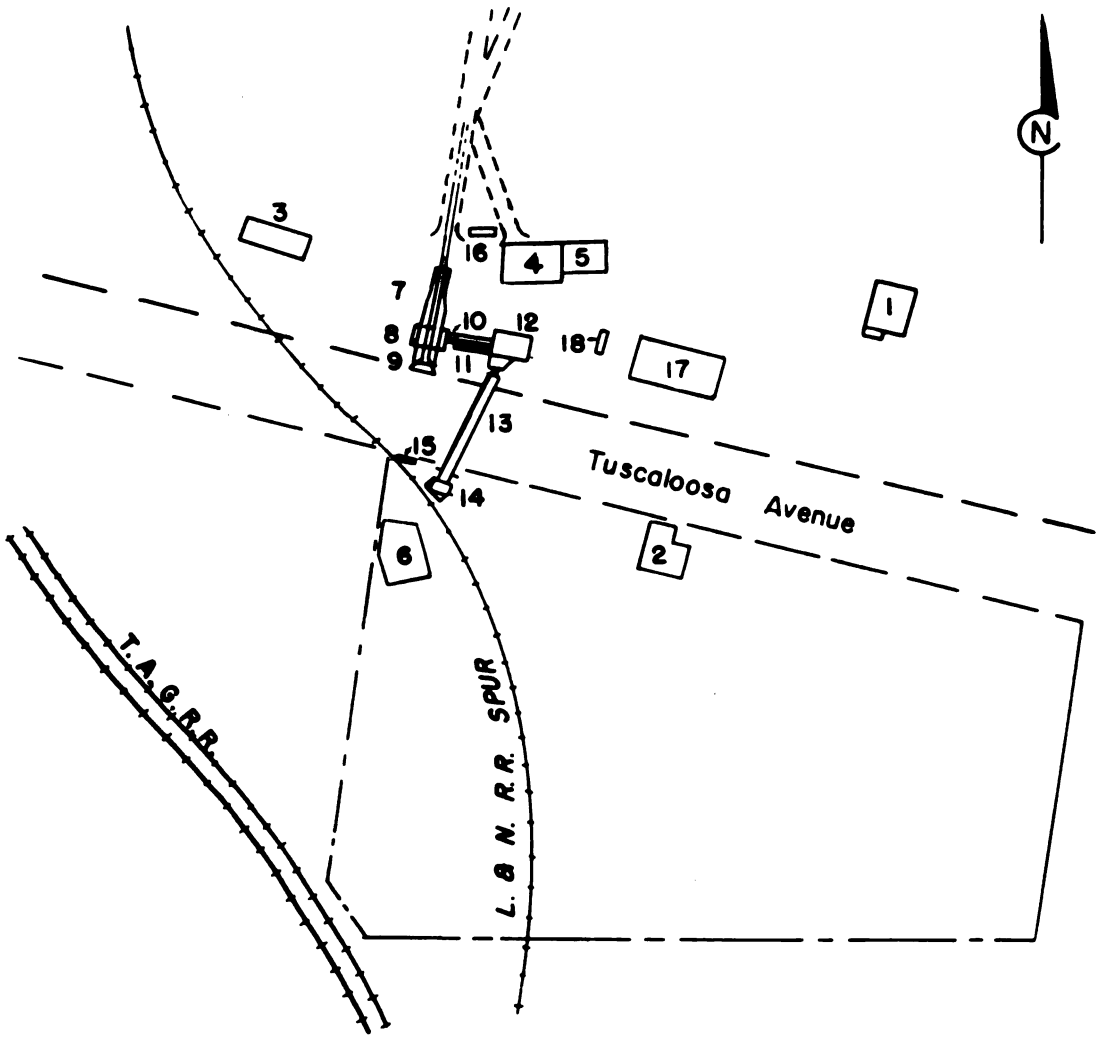

LEGEND

1. Official Residence.
2. Mine Office.
3. Change House.
4. Blacksmith Shop.
5. Compressor House.
6. Hoist House.
7. Incline and Dumping Ramp.
8. Mine Bin.
9. Headframe.
10. Feeder Plate.
11. Picking Belt.
12. Rock Crusher.
13. Conveyor Belt to R.R. Bin.
14. R.R. Bin.
15. Mine Hoist Cable Tower.
16. Air Receiver.
17. Alabama Power Co. Substation.
18. Transformer Bank.

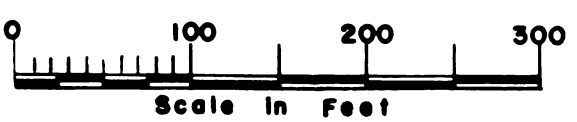

Figure 6. - Plan of surface plant.

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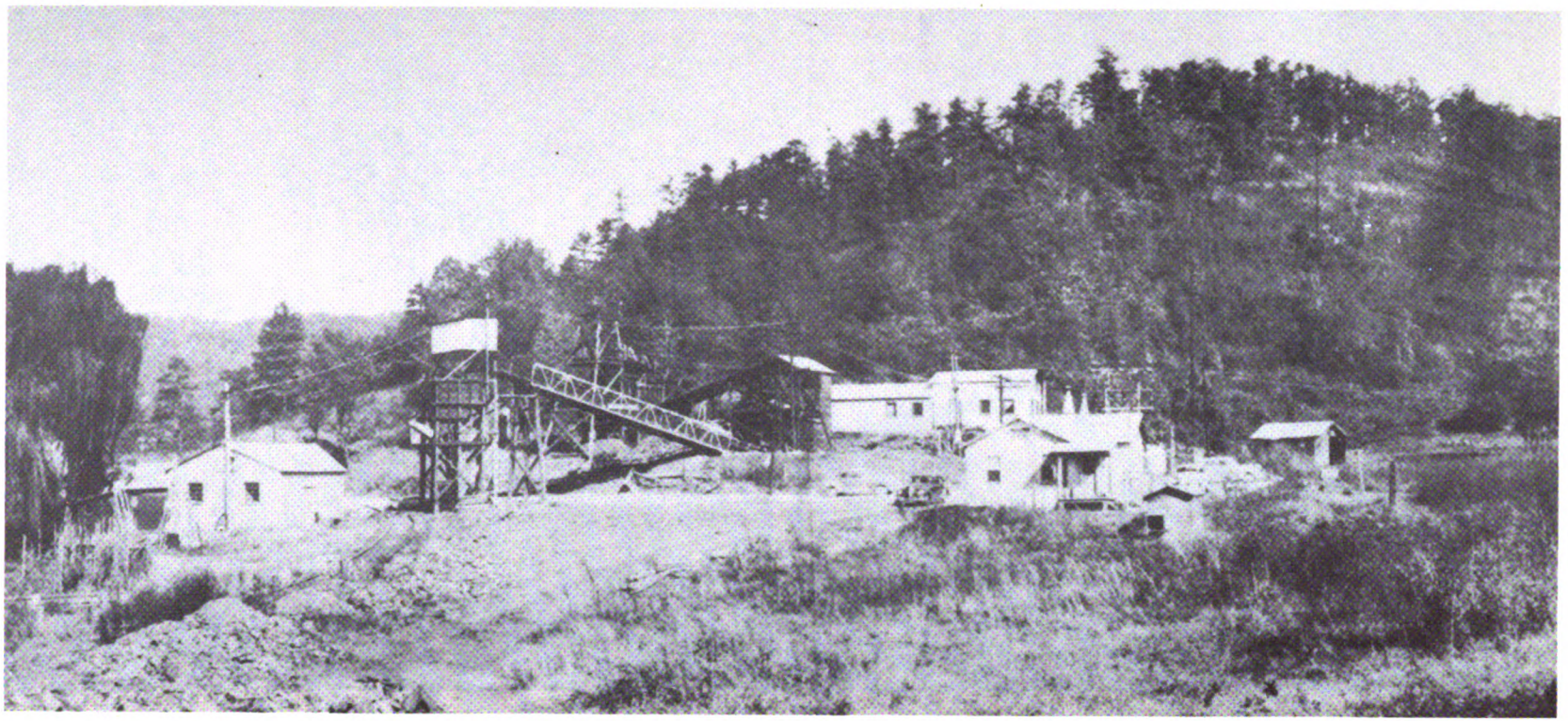

Figure 7. - View of surface plant, looking north across southwest end of Shinbone Ridge.

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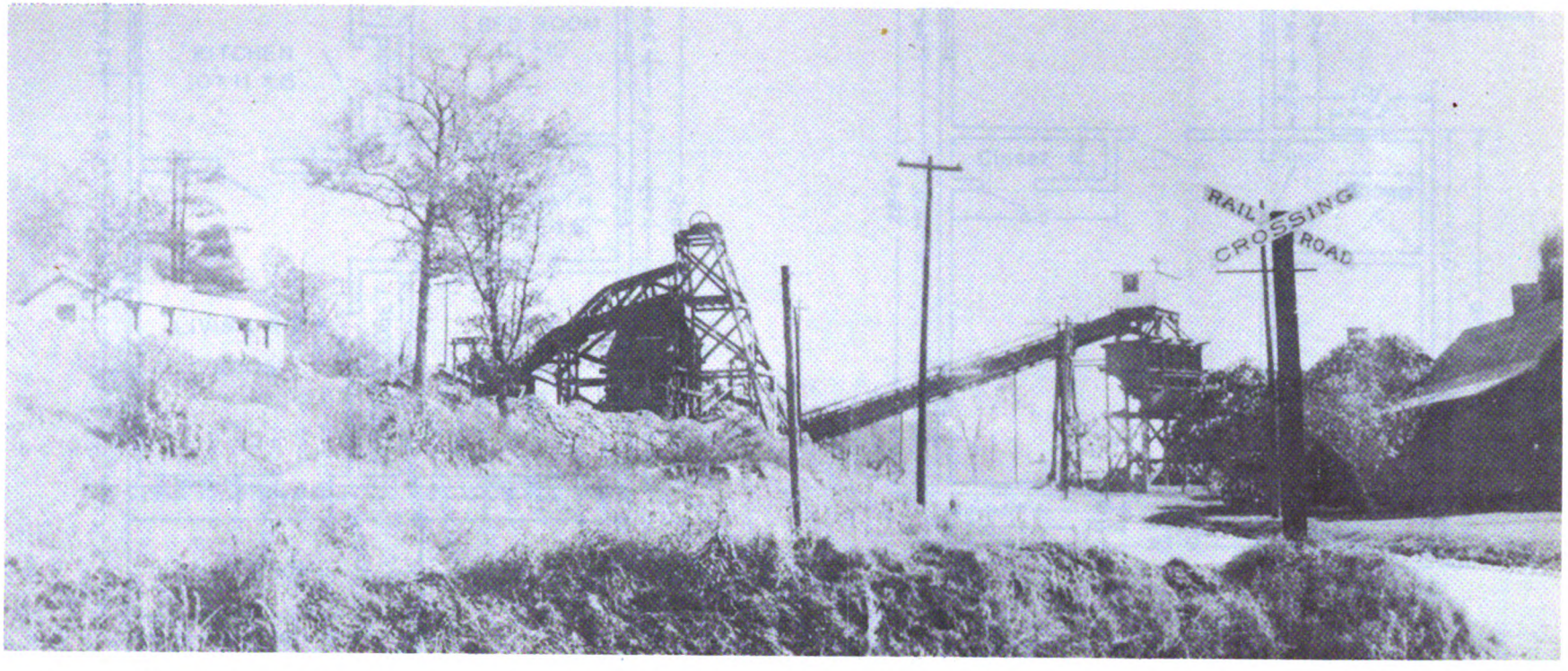

Figure 8. - View of surface plant, looking southeast, showing change house, incline structure, mine bin, head frame, conveyor across Tuscaloosa Avenue, and railroad loading bin.

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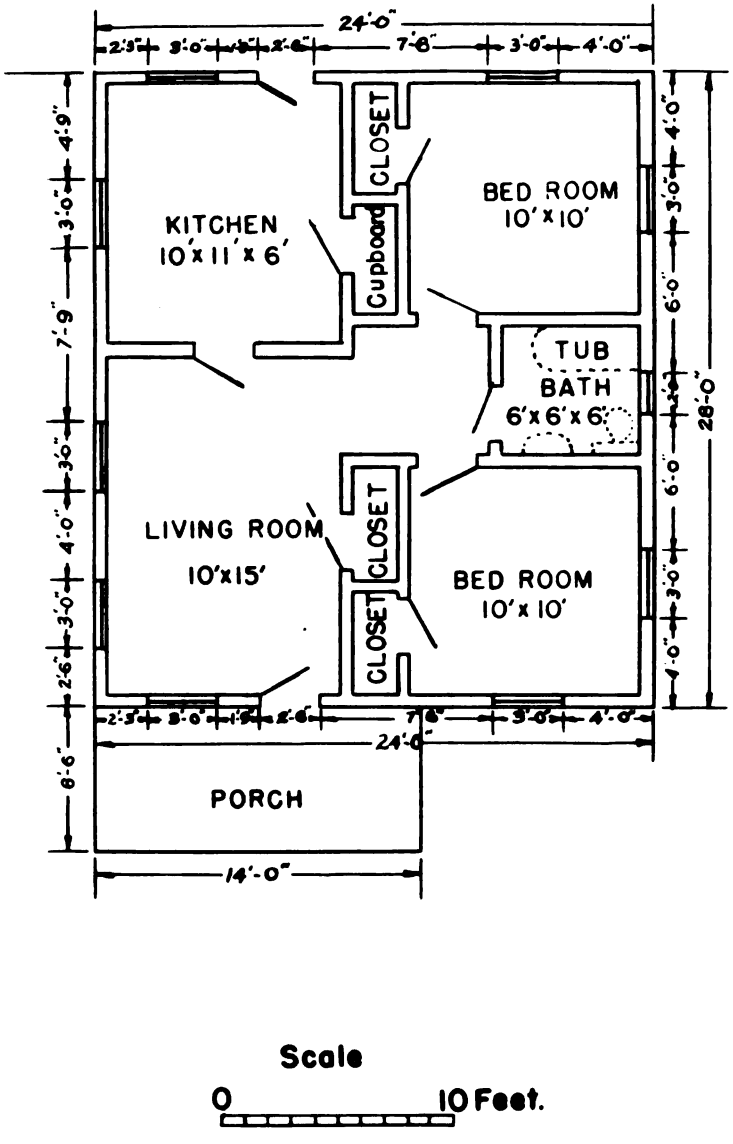

Figure 9. - Floor plan of official residence.

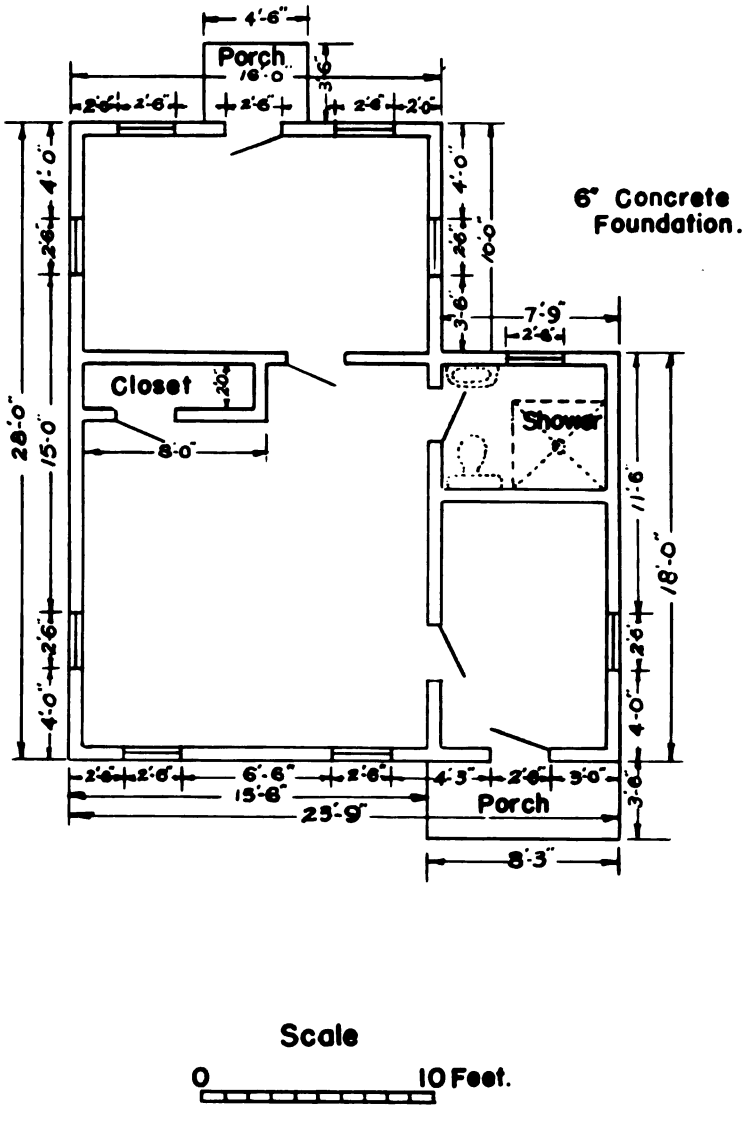

Figure 10. - Floor plan of mine office.

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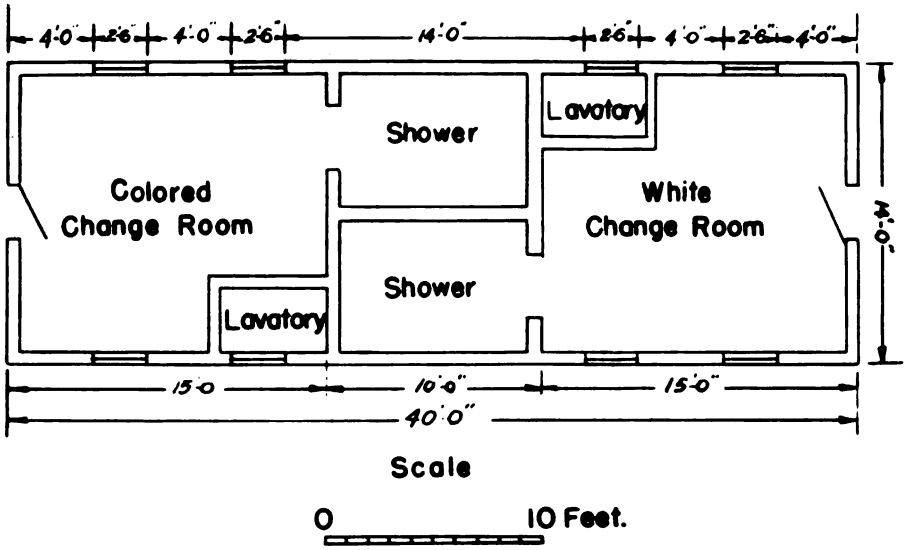

Figure 11. - Floor plan of change house.

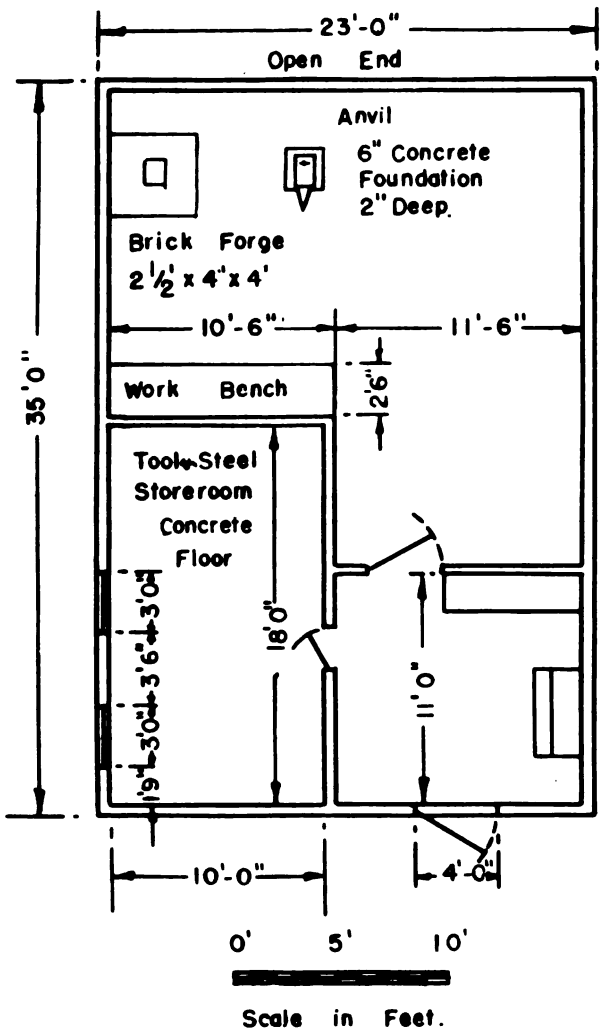

Figure 12. - Floor plan of blacksmith shop.

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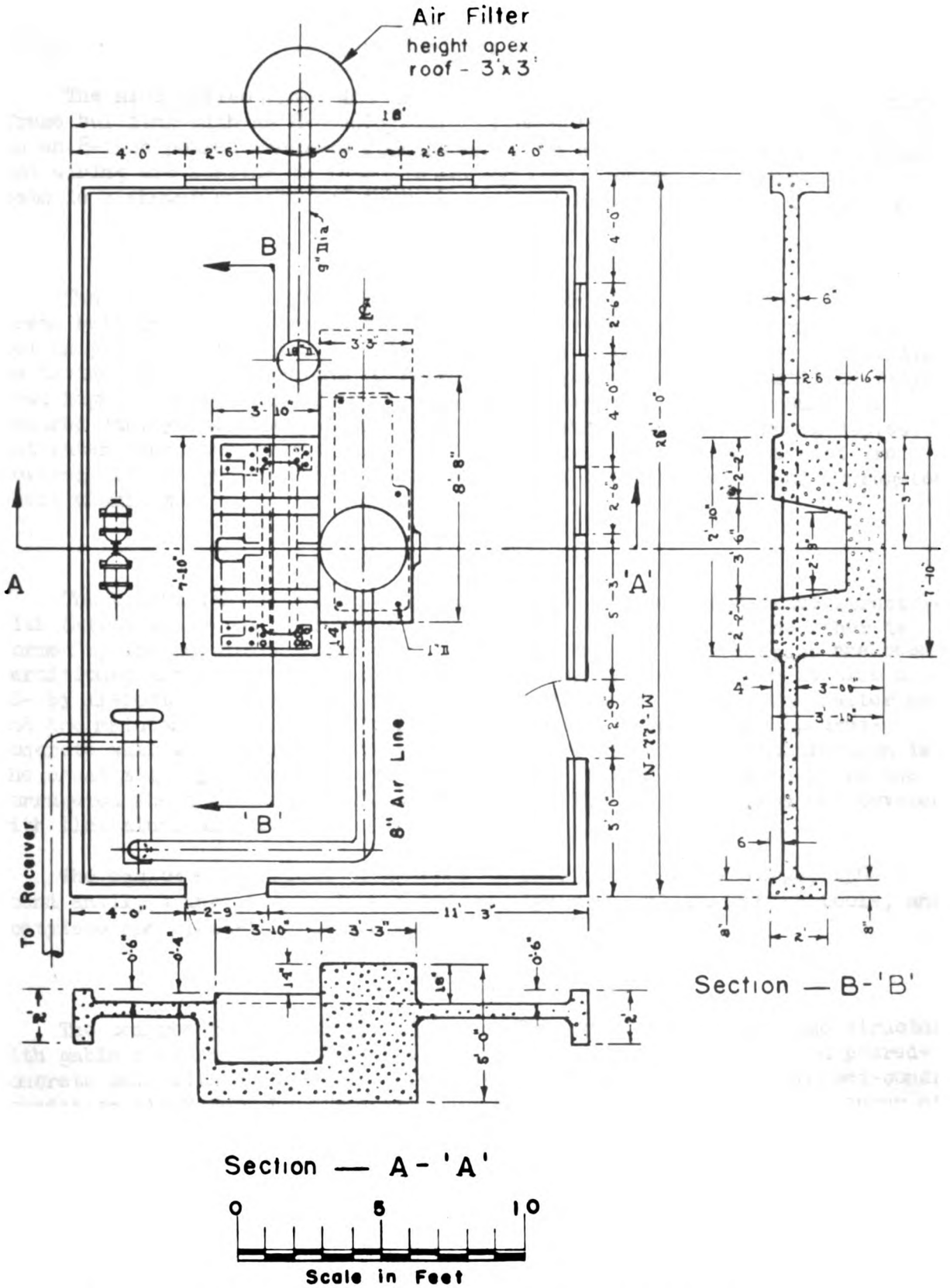

Figure 13. - Floor and foundation plan of compressor house.

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Mine Office

The mine office (fig. 10) is a 16- by 28-foot, two-room, single-story frame building with an 8- by 18-foot kitchenette and shower room added, all on an 8-inch poured concrete foundation. The construction finishing, plumbing, and wiring are similar to those in the official residence, except that the bath is a shower and the building is sided with corrugated sheet aluminum.

Change House

The change house (figs. 8 and 11) is a 14- by 40-foot single-story frame building set on framed timber stringers and girders over pine posts set on 3-inch footboards. Walls are 8 feet 10 inches high, and the building is divided into two sections or rooms by an open-top wooden partition 7-1/2 feet high. The front half is for white employees and the rear half for colored employees. The building is equipped with two coal-burning stoves, hot water tank, two lavatories, and two showers. The walls and roof are covered with tongue-and-groove pine sheathing, building paper and corrugated sheet aluminum.

Blacksmith Shop

The blacksmith shop (fig. 12) is a 23- by 35-foot wood-frame structure with 8-foot walls and gable roof. One end is left open, and the other is formed by the adjoining compressor house. A 12- by 18-foot space has been partitioned and floored with concrete for a supply room. There is also a 10- by 11-foot partitioned space for charging miners' lamps. The latter area and the main shop have dirt floors. The foundation is a 6-inch poured-concrete wall with anchor bolts set on 4-foot centers. The construction is the usual mill type, with sheathing strips on 27-inch centers to which the corrugated sheet -aluminum siding is nailed. The roof is decked and covered with flat aluminum sheets.

The equipment consists of a 4- by 4- by 2.5-foot brick forge, 150-pound anvil, 4-inch bench vise, a 6-inch pipe vise, miscellaneous tools, and acetylene and electric arc-welding units.

Compressor House

The compressor house (fig. 13) is an 18- by 26-foot wood frame structure with gable roof and 12-foot side walls. The foundation is a 9-inch poured-concrete wall with anchor bolts set at 4-foot centers. The reinforced-concrete foundation block for the air compressor and drive motor occupy the center of the floor space. A 6-inch concrete floor covers the balance. The structure is the usual mill type with sheathing strips on 2-1/2-foot centers. Roof sheathing strips are on 20-inch centers. The building is sided and roofed with corrugated sheet aluminum.

The equipment consists of a Sullivan, angle 2-stage air compressor complete with unloader and intercooler, rated at 1,495 cubic feet of free air per minute and driven by a 300-hp. General Electric synchronous motor.

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There is a Sullivan aftercooler and General Electric motor generator set and panel board with the necessary electrical attachments. The compressor is equipped with a Mercoid control and a Sullivan 3- by 3-foot intake filter. All of this equipment was purchased from the War Assets Administration at Birmingham, Ala., for $5,500.

Hoist House

The hoist house (fig. 14) is a five-sided wood frame structure of 800 square feet floor space, set on a 9-inch poured-concrete foundation with anchor bolts set on 4-foot centers.

The building is sheathed and roofed with corrugated sheet aluminum fastened to sheathing strips on 2-foot centers.

The reinforced-concrete foundation for the hoist and drive motor is surrounded by a 6-inch concrete floor.

A part of the building is used as a repair shop and for storage.

Electric control panels, resistance frames and circuit breakers are housed in a small corner room framed by 2- by 4 pine lumber covered with wire netting.

The 6- by 6-inch posts in the front wall of the building are diagonally braced on the outside by an 8- by 8-foot bolted frame made up of 3- by 6-inch posts, 2- by 6-inch braces and a 4- by 6-inch cap. The cap is bolted to the building posts and supports two 5/8-inch guy cables running from the side anchor bolts of the hoist to the cable tower outside the building.

The hoist was built by the Connellsville Manufacturing & Mine Supply Co., Connellsville, Pa. The drum is 4 feet 4 inches long by 5 feet diameter and is fitted with a post brake and friction clutch. Drive is through gears on a jack shaft mounted on the cast-steel hoist frame. The motor is a 200 hp. Westinghouse induction variable-speed type. The gear reduction ratio from motor to hoist drum is 21 : 1. The hoist, complete with motor and electrical equipment, was purchased secondhand for $7,000 delivered to the mine.

Head Frame and Mine Bin

The head frame and mine bin (fig. 15) are built as a unit, including the skip incline and dumping ramp. Material consists of round-pine bearing posts 11 to 15 inches in diameter and sawed-pine dimension lumber. The bearing posts are anchored to concrete pedestals, and the entire structure is tied together with 3/4-inch steel rods and pins.

For convenience in description, the structure is divided into four parts:

1. - Skip incline and dumping ramp. This includes bents numbers 1, 2, and 3 and cross braces to bent 4 and the dumping ramp over the mine bin

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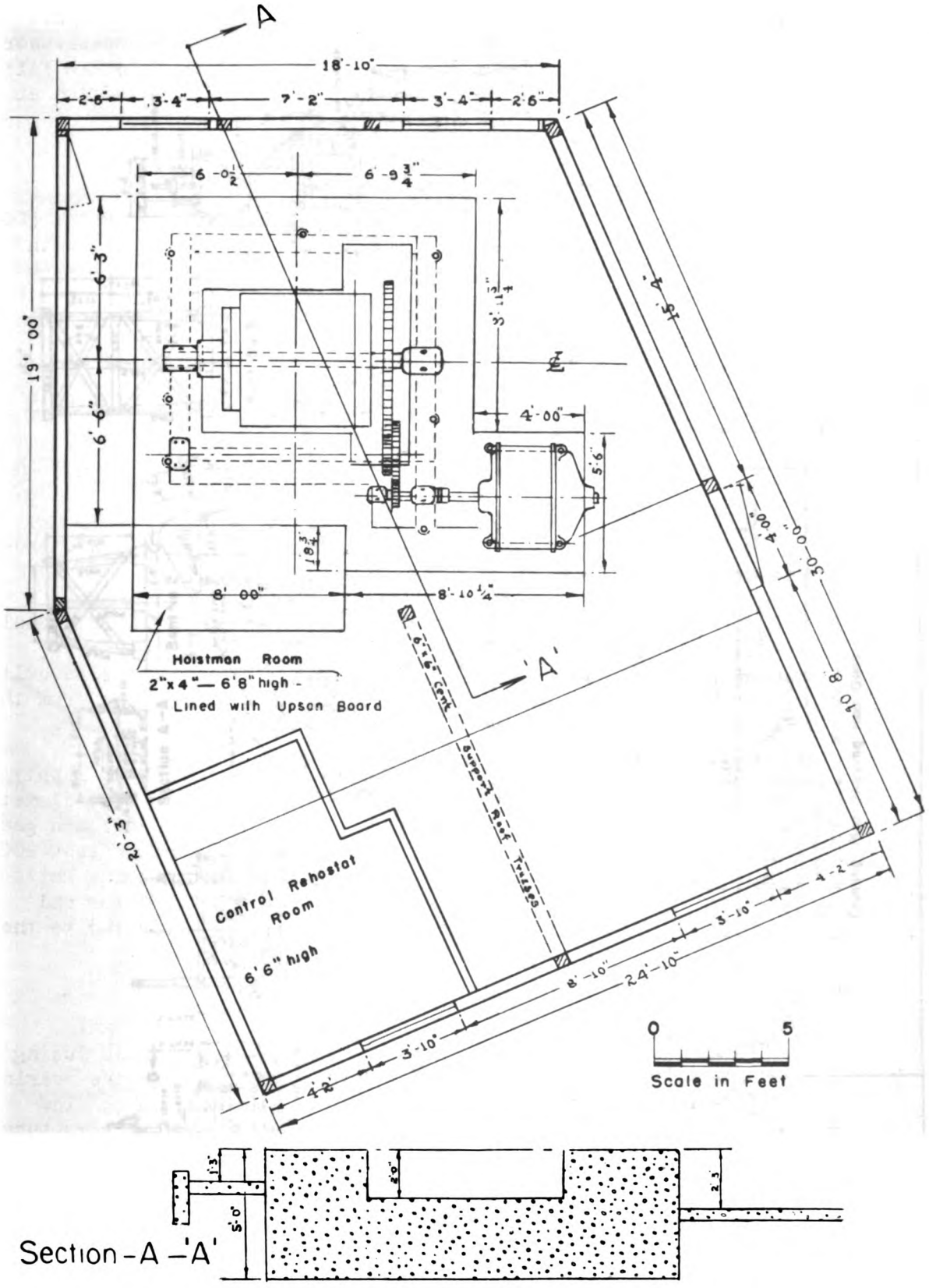

Figure 14. - Floor and foundation plan, hoist house.

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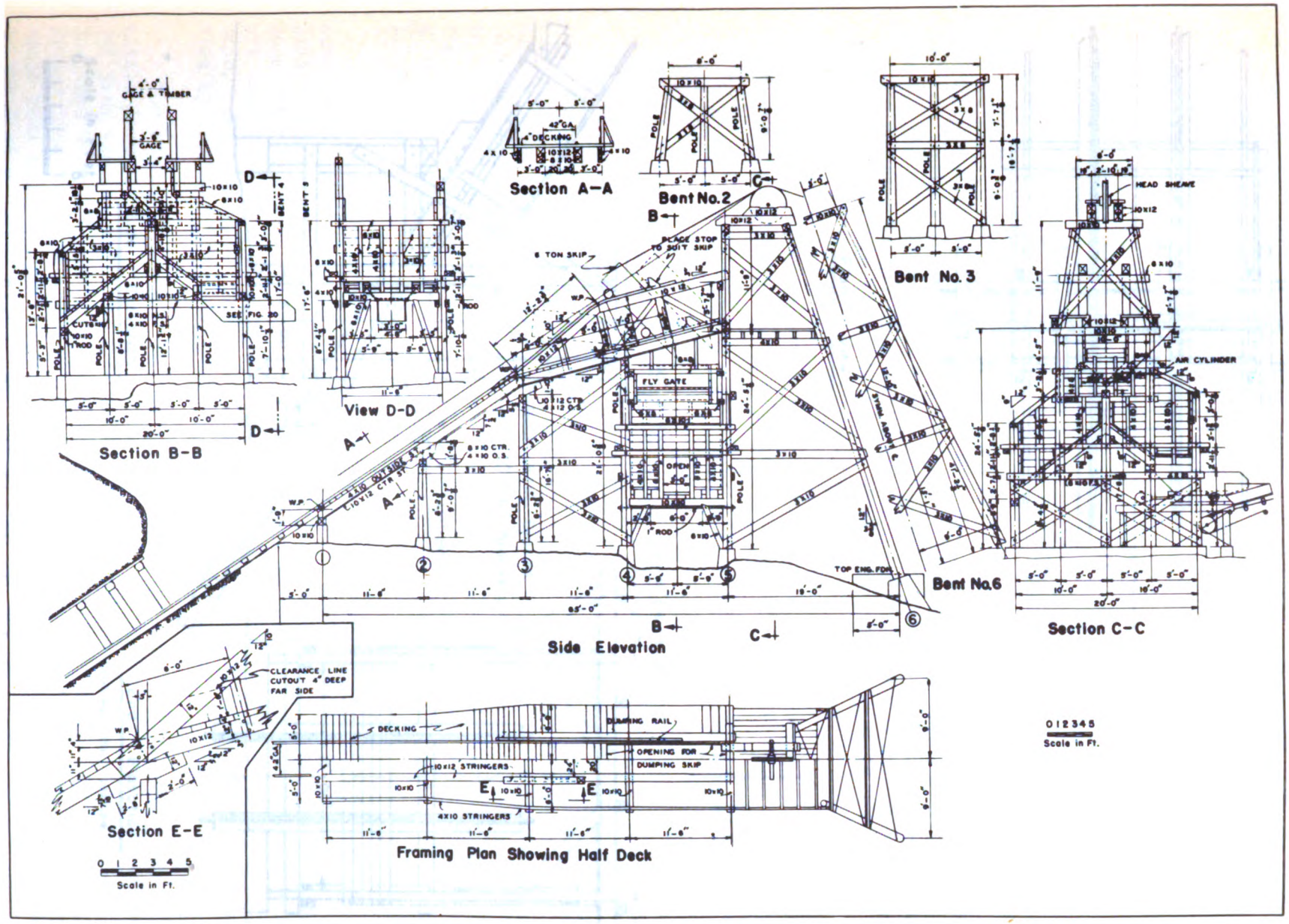

Figure 15. - Head frame and mine bin.

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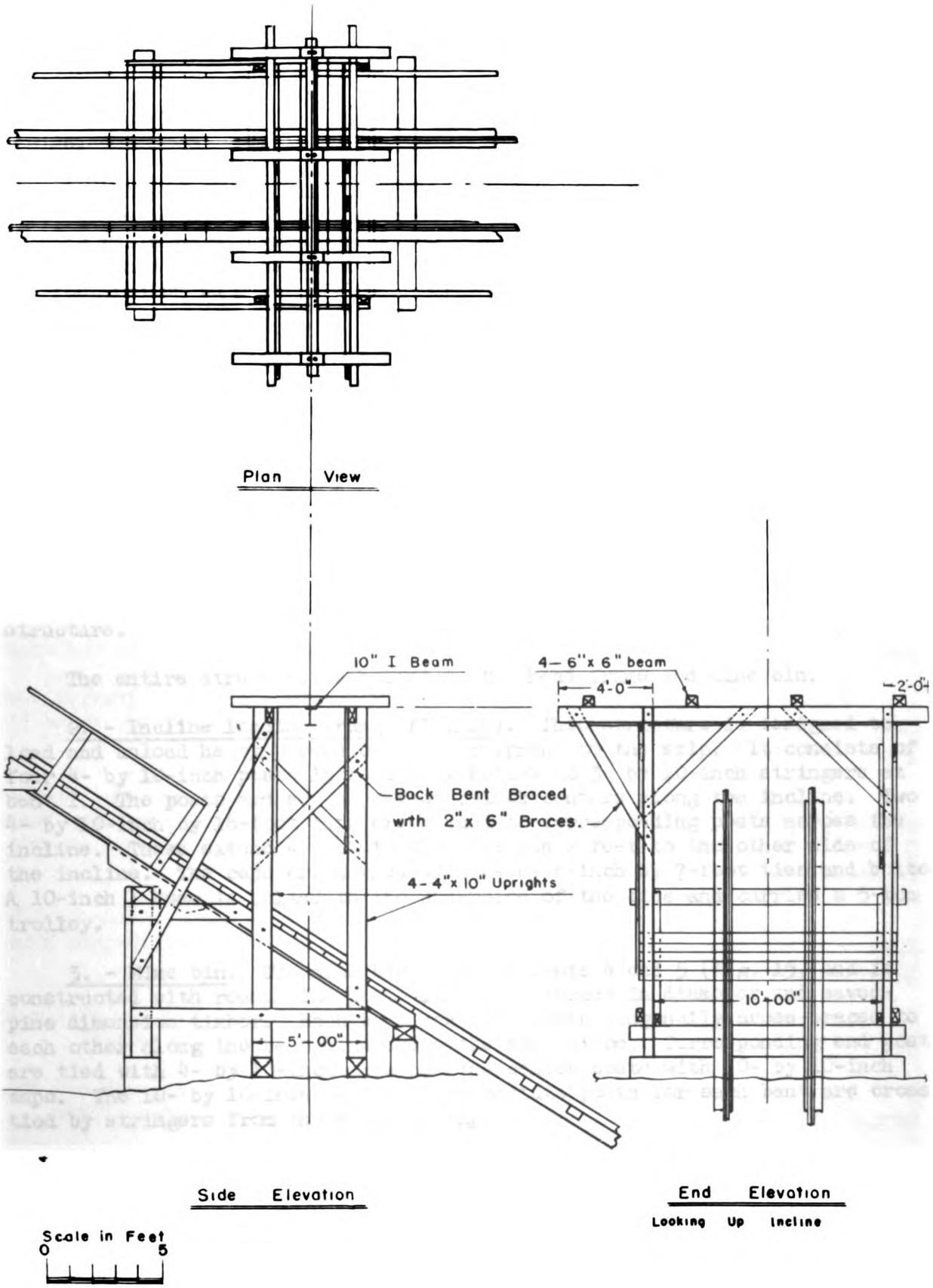

Figure 16. - Incline loading frame.

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(figs. 8 and 15). The slope track is 45-pound rails laid on 42-inch gage. The slope angle of 33° is continued up to bent 3, where the dumping ramp begins.

The dumping ramp consists of the 42-inch mine-slope track extended on a 14° grade to accommodate the front wheels of the skip and 48-inch-gage dumping rails to engage the extended rear wheels of the skip. The latter are laid on a 40° grade for 10 feet, then change on the arc of a circle with a 7-foot radius to a 14° grade, paralleling the lower rails at a distance of 5.43 feet.

Bents are made of 11- and 12-inch round posts with 10- by 10-inch caps and 3- by 8-inch diagonal bracing. Braces between bents are 3- by 10-inch timber. Two 10- by 12-inch stringers support the rails and two 3- by 10-inch side stringers parallel them for walkways. The stringers are decked throughout with 3-inch plank except over the skip dump. The structure is tied together with 3/4-inch steel rods and pins.

Stringers for the dumping rail structure are 10 by 12 inches with 8- by 8-inch posts and 6- by 6-inch diagonal bracing.

A 2- by 4-inch rail set on 4- by 6-inch posts guards either side of the structure.

The entire structure is bolted to the head frame and mine bin.

2. - Incline loading frame (fig. 16). This structure is designed to load and unload heavy pieces of mine equipment to the skip. It consists of four 4- by 10-inch posts 15 feet long bolted to 3- by 10-inch stringers at bent 1. The posts are set at 4-foot 2-inch centers along the incline. Two 4- by 10-inch by 16-foot caps are framed to corresponding posts across the incline. These extend 4 feet to one side and 2 feet to the other side of the incline. The caps are decked with 6- by 6-inch by 7-foot ties and bolted. A 10-inch I beam is bolted to the underside of the ties and carries a 5-ton trolley.

3. - Mine bin. The mine bin includes bents 4 and 5 (fig. 15) and is constructed with round pine posts 11 and 12 inches in diameter and sawed-pine dimension timber. Each bent has five posts diagonally cross-braced to each other along the bent line below the bin bottom. Corresponding end posts are tied with 4- by 10-inch caps and the center posts with 10- by 10-inch caps. The 10- by 10-inch caps of intermediate posts for each bent are cross-tied by stringers from the dumping ramp.

The bin is roughly 12-1/2 by 21 feet in plan and is divided in the middle into a waste rock bin and an ore bin. The bottom of each side slopes 36° from the center. The floors of 3- by 10-inch planks are laid on six inclined 4- by 10-inch stringers supported on four 10- by 10-inch girts framed into the bent posts. The inclined portion of the ore-bin floor extends only halfway, the remainder being flat, providing openings for discharge to the feeder plate, picking belt, and crusher.

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The bins are tied with a timber tie of 6- by 10-inch by 14- and 23-foot timbers bolted together at their ends and to the bin posts about 11 feet above the foundation of bent 5.

The slope bottom of the ore bin is lined with 45-pound steel rails, and the flat bottom section is lined with 3/8-inch steel plate. The bottom of the waste bin is lined with 3/8-inch steel plate.

A steel fly gate, 3-1/2 by 8 feet, extends across the middle of the bin. It is constructed of two 3/8-inch steel plates bolted to a 4-inch steel frame, which in turn is welded along one side to a section of heavy 3-inch pipe 10-1/2 feet long. This pipe is the bearing axle on which the gate swings to cover either the ore or waste bin. Six-inch bearing blocks on each end of the pipe axle are bolted to a 10- by 10-inch cap extending across the center of the bin from the middle posts of bents 4 and 5. The fly gate is operated by a 5-inch by 2-1/2-foot compressed-air cylinder attached by proper linkage to a 1-1/2-foot steel lever arm welded on the pipe axle. The cylinder is controlled by a four-way valve on the operating floor of the crusher house.

Waste is drawn through a wood stop-board chute, 3 feet wide, built into the side of the waste bin.

Ore discharges through a 4- by 4-1/2-foot opening in the flat floor portion to the hopper of the plate feeder for the belt conveyor to the crusher.

The ore bin has a maximum capacity of 343 cubic feet, with gravity working capacity of about 225 cubic feet. The maximum capacity of the waste bin is 443 cubic feet and the working capacity 300 cubic feet.

4. - Head frame. The head-frame section (fig. 15) includes the 11-foot 9-inch pony bent on the cap of bent 5, bent 6, and all bracing between bents 5 and 6. The base of the crown block is 24 feet 5 inches above the concrete foundation of bent 5.

The pony bent is built with two 10-inch round-pine posts, a 10- by 10-inch cap, and braced with 3- by 10-inch plank. Bent 6 has two 15-inch pine posts, a 10- by 10-inch cap and 3- by 10-inch bracing.

The crown blocks are two 10- by 10-inch by 7-foot and two 10- by 10- by 5-foot 9-inch timbers bolted to the caps of the pony bent and bent 6.

The sheave wheel is 4 feet in diameter with cast-steel rim and hub and wrought-iron spokes. The bearing blocks are bolted to the crown blocks.

Mine Hoist-cable Tower

The mine hoist-cable tower (fig. 17) is a single-bent, two-post structure 29-1/2 feet high between the head frame and hoist house. It consists of two 10- by 10-inch by 33-1/2-foot posts, 4 feet of which are buried in the ground, and 3- by 8-inch plank bracing.

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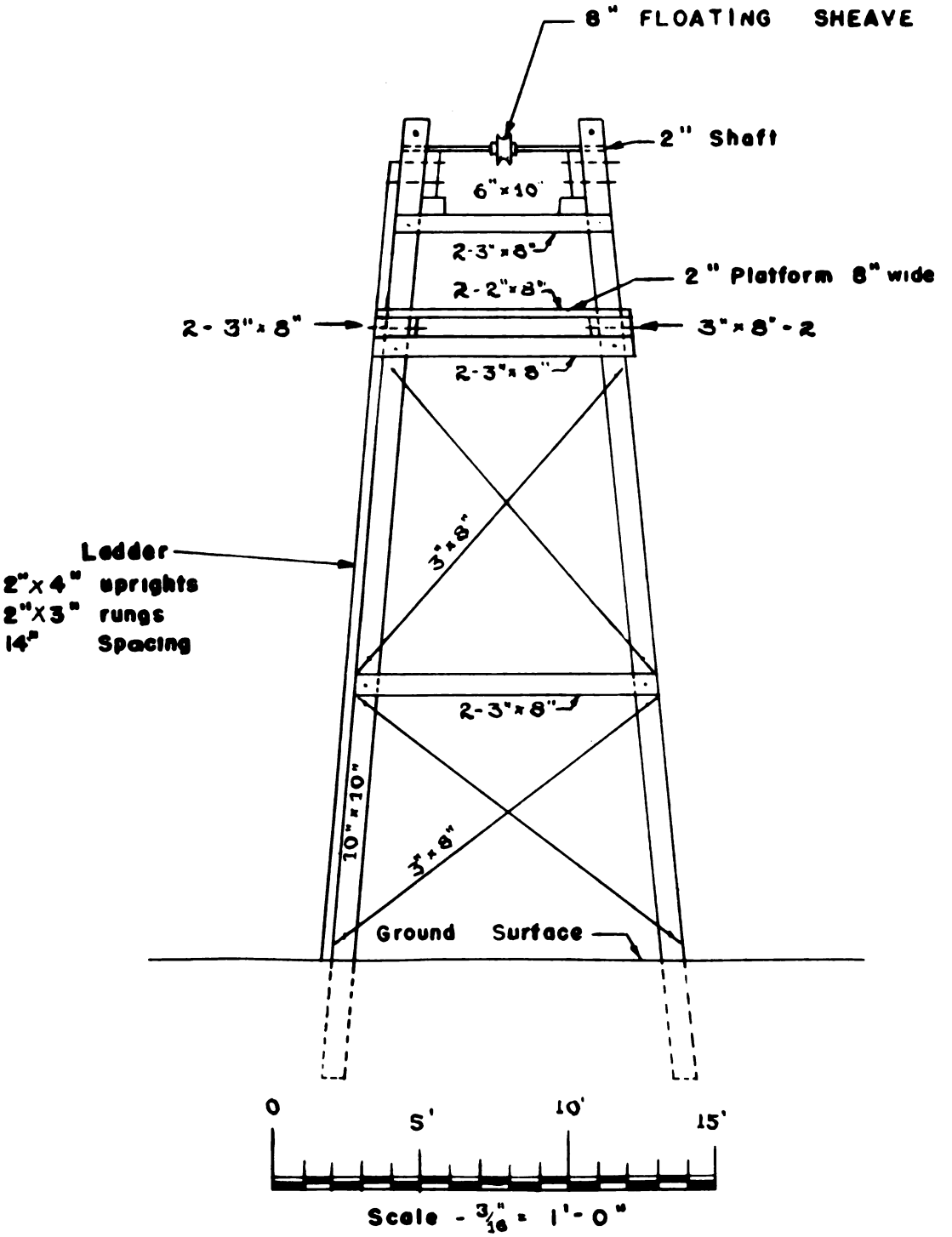

Figure 17. - Mine hoist-cable tower.

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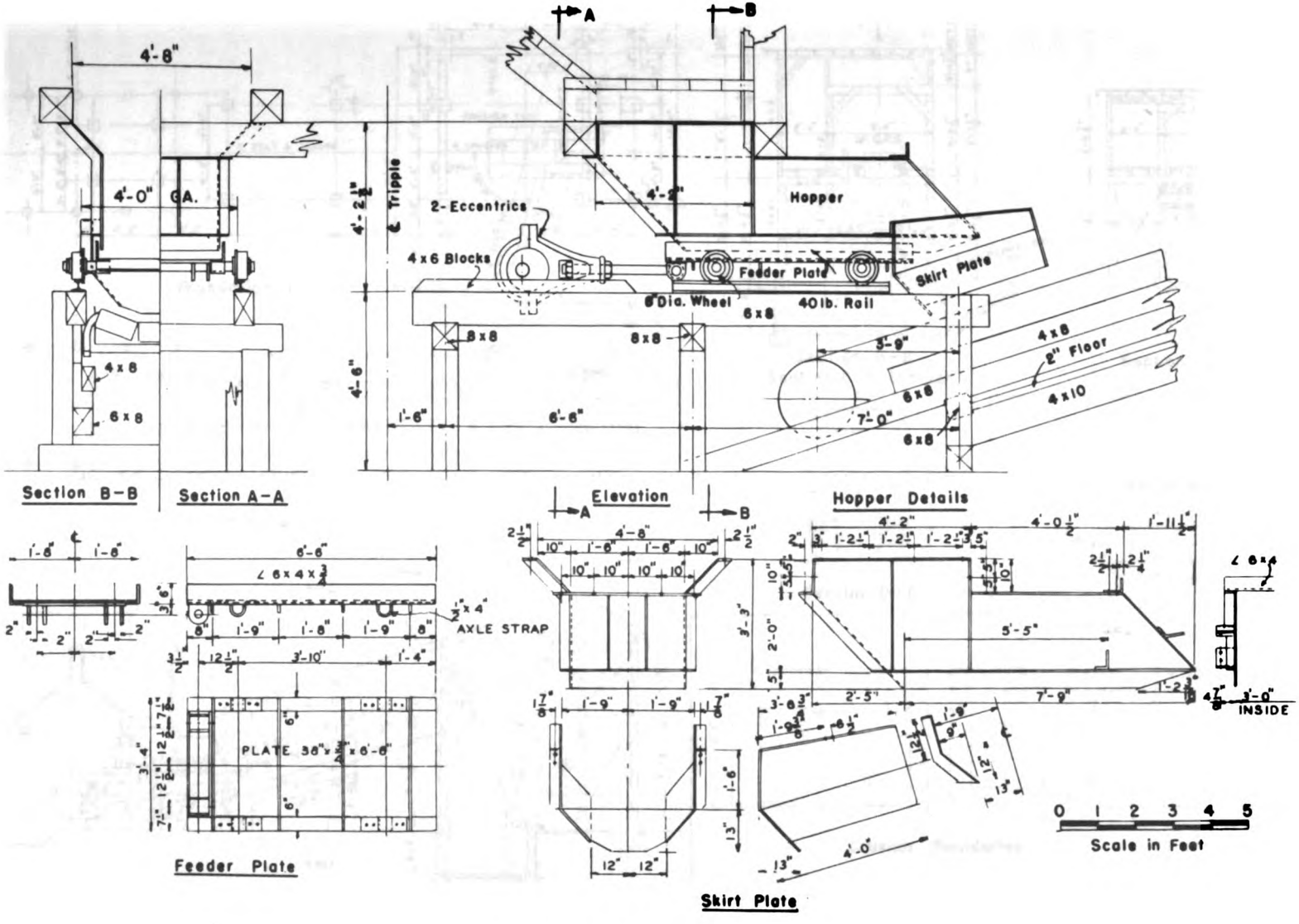

Figure 18. - Feeder plate.

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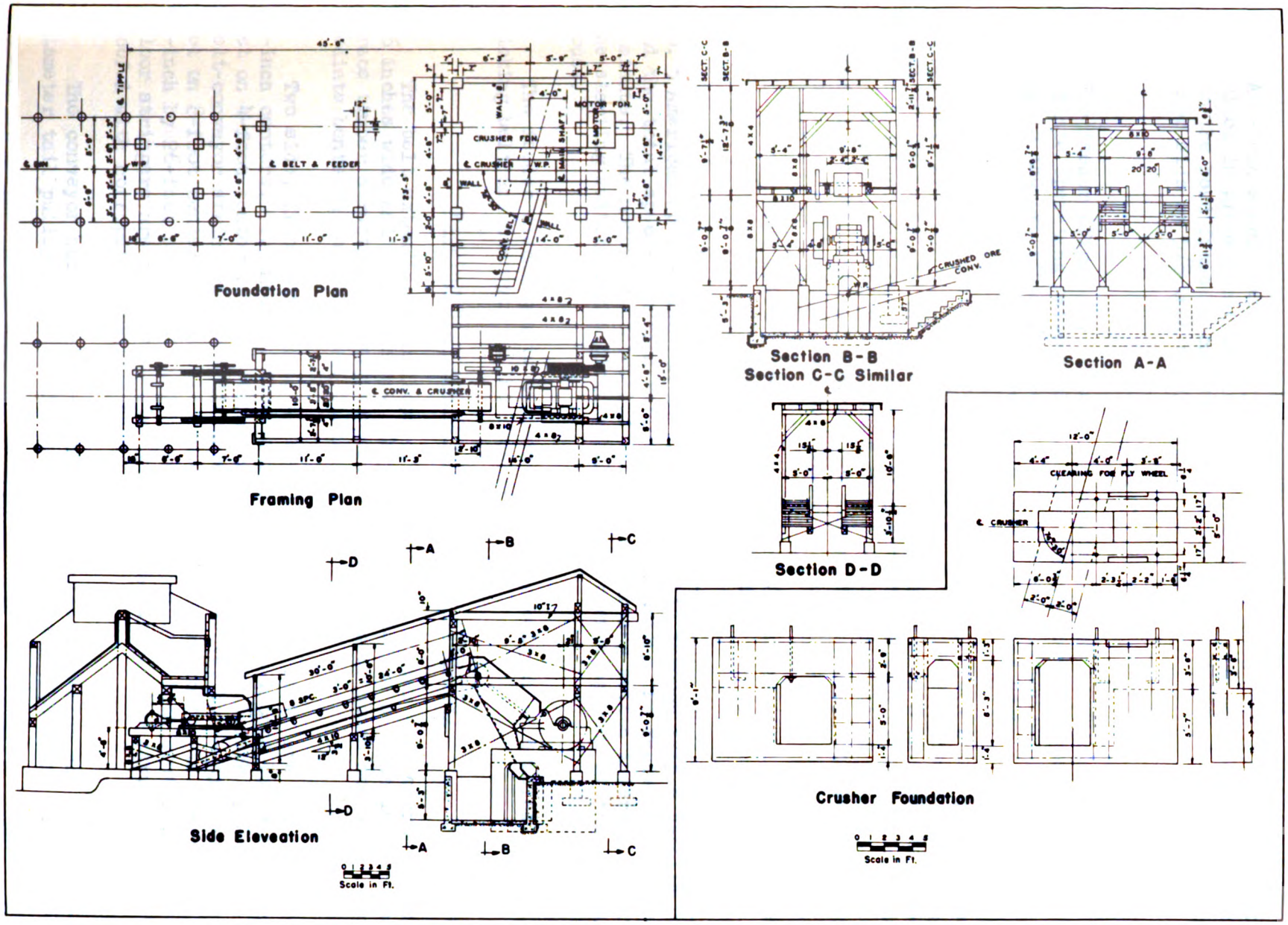

Figure 19. - Picking belt and crusher.

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A 2-inch steel shaft, carrying an 8-inch floating sheave wheel, is set and bolted in grooves cut in the top of each post. The tops of the posts are tied to the head frame on one side and to the anchor bolts of the hoist on the other side by 5/8-inch steel cables.

Feeder

The feeder (figs. 15, 18, and 19) consists of an eccentrically driven steel plate operating between skirt plates bolted to the hopper under the opening in the ore bin. The feeder plate and drive motor are mounted on a wooden frame 6 feet wide, 15 feet long, and 4-1/2 feet high.

The feeder plate itself (fig. 18) is made of 3/8-inch steel plate reinforced with 1/2- by 3- and 1/2- by 4-inch bars. The sides are 6- by 4-inch steel angles welded to the plate. Two 4-inch axles with 8-inch wheels on 4-foot 8-1/2-inch gage are attached by straps to the bottom of the plate. The plate carriage reciprocates on two 5-foot 10-inch sections of 40-pound rails bolted to 6- by 10-inch stringers. The eccentric throw of the plate is 2 inches, which can be increased to 4 inches.

The hopper and skirt plates are made of 3/8-inch steel plate welded to 1/2- by 3-inch steel bars. The hopper is bolted to the bottom of the ore bin.

The feeder is driven by a Westinghouse 870-r.p.m., 5-hp. motor through a No. 5 American speed-reduction unit. The drive is through triple V-belts, and the total speed-reduction ratio is 39:1, actuating the feeder at 22 strokes a minute. The motor is controlled through a starting switch interlocked with the starting switch of the picking belt in the operating room of the crusher house.

The feeder discharges to a 36-inch conveyor belt which doubles as a picking belt and conveyor to the crusher.

Picking Belt and Crusher Conveyor (Fig. 19)

The belt extending on a slope of 18° from the feeder to the crusher is 36 inches wide and 30 feet long. The belt is carried on a suitable bent-and-brace timber structure, partly supported by the crusher house and with intermediate bents on concrete pedestals.

Two side, floor stringers, 4- by 10 inches by 24 feet, are set on 9-foot, 8-inch centers. Two middle, floor stringers, 6- by 10 inches by 24 feet, are set on 4-foot centers; these stringers support two 4- by 6-inch by 26-foot belt-conveyor stringers, at a distance of 1 foot above, by 4- by 6-inch posts set on 8-foot centers. The belt conveyor pulleys are bolted to the 4- by 6-inch by 26-foot stringers, which are set on 3-foot 7-inch centers. The floor stringers are tightly boarded with 2-inch plank. The structure is roofed with corrugated-aluminum sheets.

The conveyor has a 30-inch-diameter drive (head) pulley and a 24-inch-diameter tail pulley complete with take-up mechanism. There are nine belt

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troughing pulleys (three 6- by 12-inch pulleys each), two 6- by 26-inch idling pulleys and a 36-inch, 32-oz., U. S. Tire & Rubber Co. rubber belt.

The conveyor is driven by a 1,700-r.p.m., 3 hp. Westinghouse motor equipped with planetary, concentric-shaft, gear reducer with a 4-inch, 15-tooth gear, which drives a 30-inch, 120-tooth gear attached to the shaft of the 30-inch, conveyor drive pulley. The total speed reduction is 198 to 1. The belt speed is 67 feet a minute.

A water spray, connected to a 1-inch fresh-water mine supply line, is installed to wash the ore on the conveyor, about 6 feet beyond the discharge from the feeder.

Crusher House

The crushing unit consists of the crusher house, a concrete foundation pit, a 12- by 24-inch jaw crusher, a 40-hp. General Electric motor, a feeder apron with grizzly, discharge hopper, and skirt plate. The reinforced-concrete crusher foundation block was designed to accommodate the loading end of the conveyor to the railroad bin. Construction details are shown in figure 19.

The crusher house is a wood frame structure 19 feet 8 inches by 15 feet in plan by 17 feet 11 inches high. The construction is the usual mill type, two bents high, with the operating floor on the lower bent. The roof is covered with corrugated sheet aluminum, and the lower portion is sheathed with 1-inch lumber.

A 6-by 6-foot control room is partitioned off on the crusher operating floor and contains the control mechanism for the crusher, feeder, belt conveyors, and the fly gate on the ore bin.

The 12- by 24-inch Blake-type jaw crusher was built by the Farrel Foundry & Machine Co., Ansonia, Pa., and was purchased secondhand. Its weight is estimated at 12 tons.

The crusher is driven by a 1,180-r.p.m., 40-hp. General Electric motor with a 12-inch, 6 V-belt pulley driving a 48-inch pulley on the crusher drive shaft. The crusher operates at 295 r.p.m. The capacity when set at 3-inch opening is estimated to be 30 tons an hour.

The feeder apron (shown in fig. 19) receives ore discharged from the picking-conveyor belt and delivers the oversize from a 3-inch grizzly to the crusher. The apron is made from 3/8-inch steel plate reinforced with 1/2- by 4-inch steel bars and 6- by 6-inch steel angles. It is 3 feet 9 inches wide at the receiving (conveyor-belt) end and 24 inches wide at the discharge (crusher) end. The floor of the apron comprises six 5-foot, 30-pound rails set at a 36° slope. The rails are set to reject plus 3-inch ore to the crusher. The minus 3-inch ore passes through the grizzly and, bypassing the crusher through a 3/8-inch steel plate chute, goes to the crusher discharge hopper.

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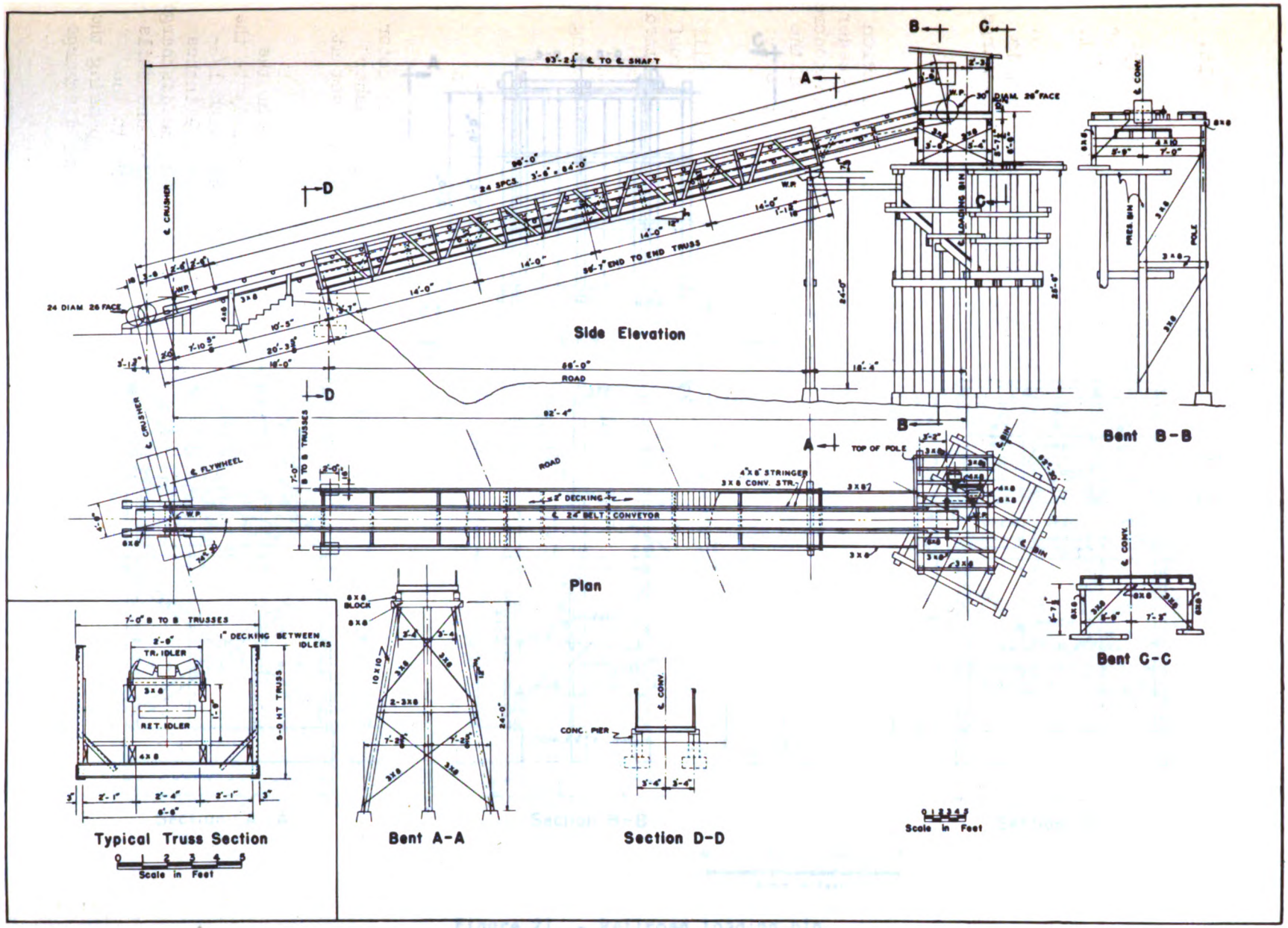

Figure 20. - Belt conveyor to railroad loading bin.

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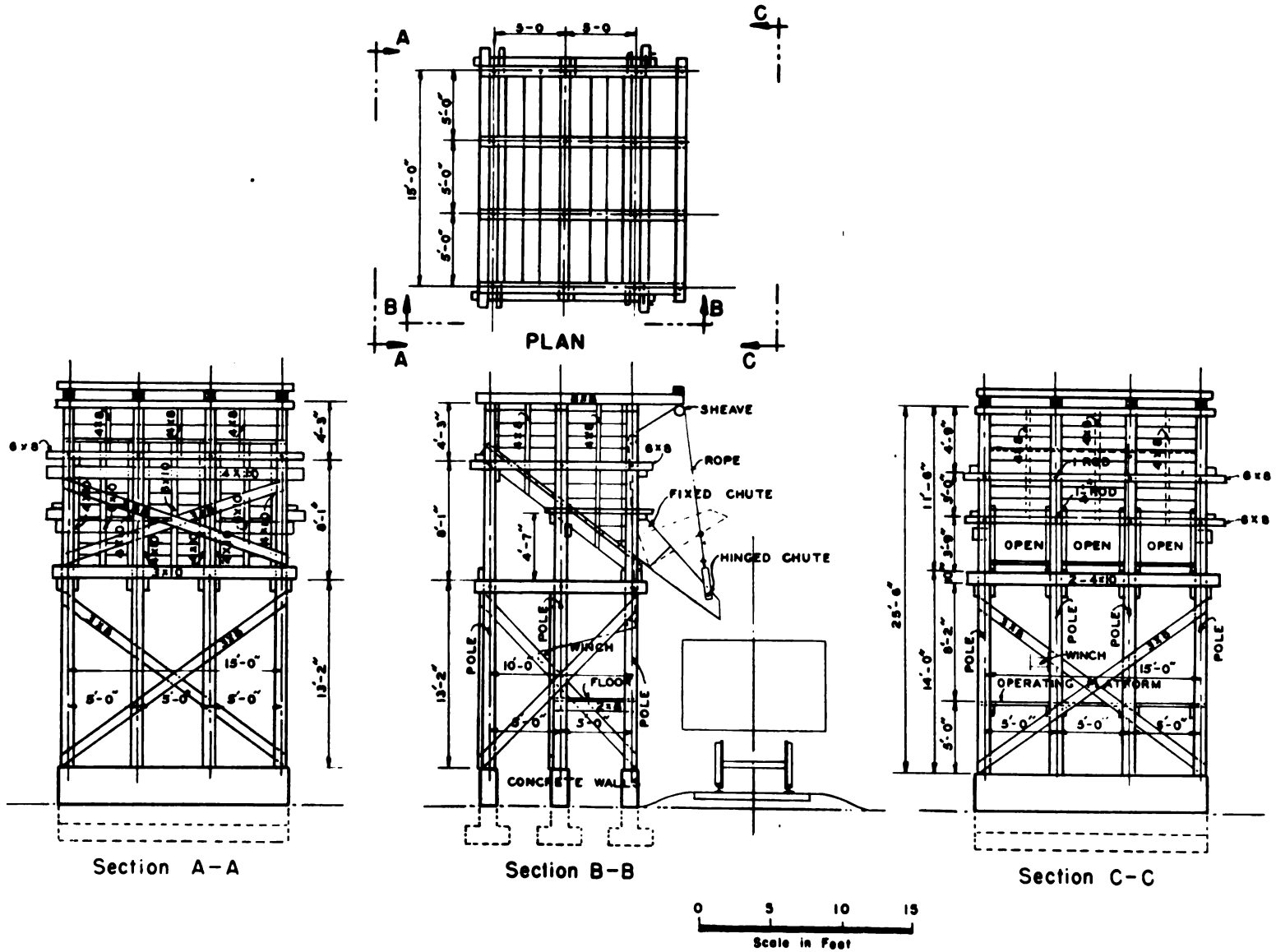

Figure 21. - Railroad loading bin.

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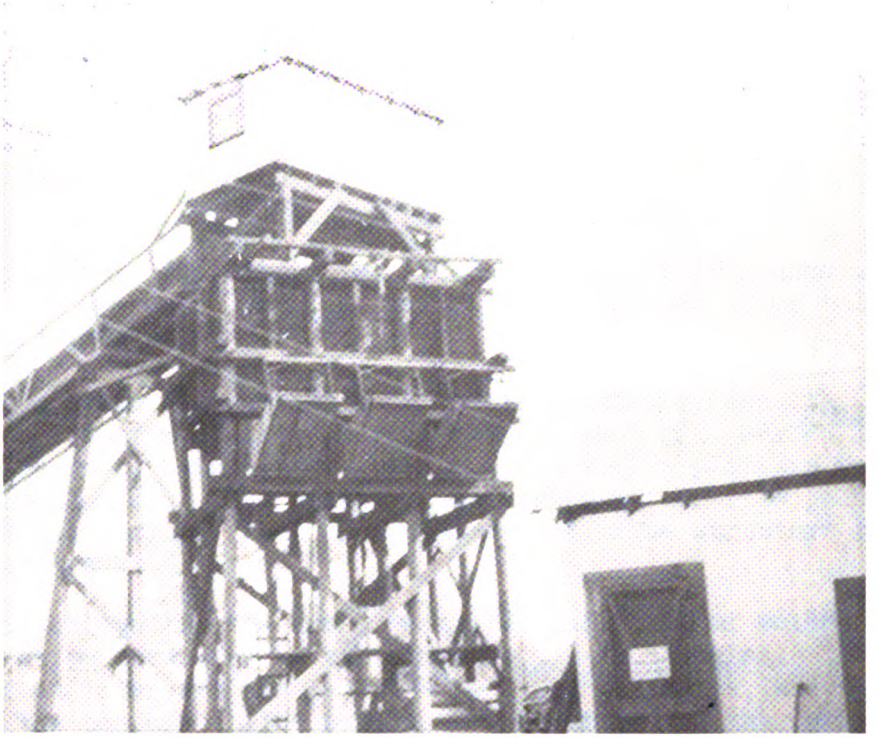

Figure 22. - Front, oblique view of railroad loading bin; part of hoist house is shown in lower right corner.

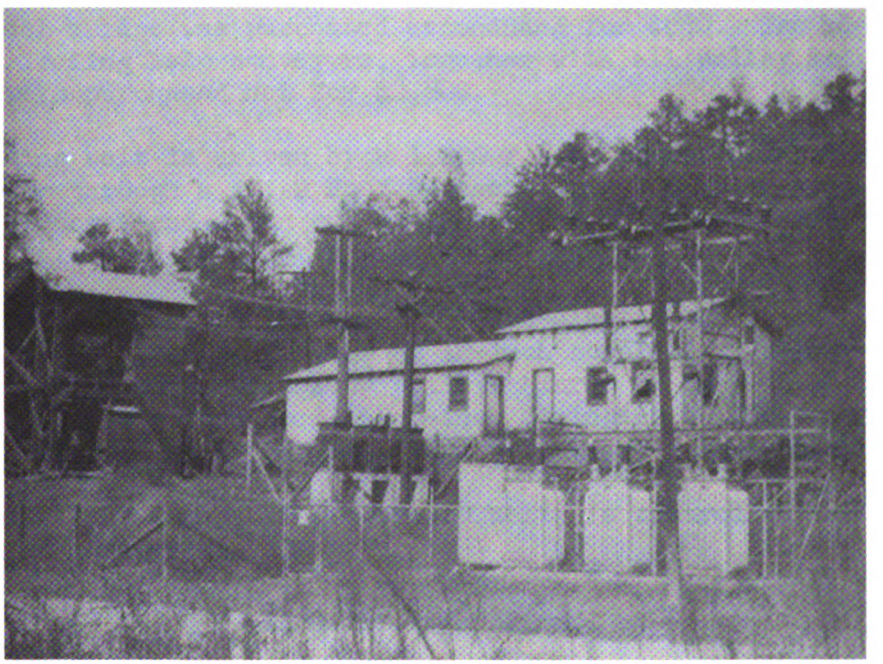

Figure 24. - View of Alabama Power Co. substation; transformer bank, blacksmith shop, and compressor house are shown in center background; crusher structure is shown at left side in background.

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The crusher discharge hopper, made of 3/8-inch steel plate, was shaped to fit the well in the crusher foundation block and feeds the crushed product by gravity to the conveyor belt discharging to the railroad loading bin.

Belt Conveyor to Railroad Loading Bin

The loading belt conveyor (figs. 7, 8, and 20) is 18 inches wide by 96 feet long and operates overhead, tail, troughing, and idler pulleys designed for a 24-inch belt.

The belt conveyor is carried on a timber structure (see fig. 20), which extends from the bottom of the concrete rock crusher pit, across Tuscaloosa Avenue, on a 59-foot, 6-inch steel bridge, to a wooden platform built on top of railroad loading bin. The bridge is supported by concrete pedestals on the lower end and a timber bent on the upper end. The structure complete is built on a 14° grade.

The steel bridge trusses are 5 feet high and built of welded steel forms. The top and bottom cords are 4- by 6-inch by 3/8-inch angles. The panel uprights at 8-foot intervals are 3- by 3- by 1/4-inch angles, and the diagonal members from the centers of the panels to the bottoms of the uprights are 3- by 3- by 1/4-inch angles.

The bottom cords of the two trusses support 7-foot lengths of 2- by 6- by 1/4-inch channels at 8-foot panel intervals. The bottom cords are braced diagonally from alternating corners of panels with 2- by 6- by 1/4-inch angles.

This steel bridge was purchased secondhand for $600. The picking belt and railroad loading belt conveyors, together with all pulley motors and drive mechanisms, were purchased new for $2,800.

The loading belt is driven by a 1,200-r.p.m., 3-hp. General Electric induction motor through a No. 2 Foot Brothers Gear & Machine Corp. gear reducer and sprocket-and-chain connections. The total speed reduction is 133 to 1 and the belt speed 85 feet a minute.

The conveyor is driven through a 36-inch-diameter by 26-inch head pulley. The tail pulley is 21-inch-diameter by 18-inch complete with take-up mechanism. The belt is carried on 26 troughing pulleys (three 5- by 9-inch pulleys each) and 9 idling pulleys bolted to 3- by 8-inch stringers of the conveyor timber a structure. It is a U. S. Rubber & Tire Co. 28-ounce 18-inch rubber belt.

This belt, like the picking-conveyor belt, is controlled through a starting box on the crusher floor.

Railroad Loading Bin

The railroad loading bin (figs. 21 and 22) is 8.75 by 14.25 feet in plan (inside dimensions) and extends 25-1/2 feet above the poured-concrete foundation walls. It has a maximum storage volume of 779 cubic feet or the equivalent of about 52 tons of ore. The working capacity is about 45 tons.

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The structure consists of three bents of four vertical posts each with posts and bents both on 5-foot centers. The construction uses round pine posts 12 inches in diameter and dimensioned, sawed timber for caps and braces. The inclined stringers are set on a slope of 36°. The sides, bottom, and ends are made with 3- by 10-inch lumber. The bottom is lined with 45-pound steel rails and the face is lined with 3/8-inch steel plate. Two timber ties surround the bin, bolted to the corner posts. Two 1-inch steel rods are also used to tie the bin at the upper timber tie line and two 1-1/4-inch steel tie rods are used in the lower timber tie line.

Three car-loading chutes (fig. 23) are bolted to the floor and frames set in openings between front bent posts. The chutes are operated simultaneously by a 1/2-inch steel cable and hand winch. The steel cable runs through a 10-inch steel block supported on cross timbers over the bin and extending over the chutes. Below the 10-inch block the cable ends in a 1-inch steel ring 2 inches in diameter. To this ring are attached three bridle cables (1/2-inch diameter) which suspend a 14-foot section of 4-inch, steel tee bar welded to tops of chutes' lift bars, 4 feet below the ring.

Railroad Spur Track

The railroad spur track (figs. 6 and 7), 1,760 feet long, was built by the Louisville & Nashville Railroad at a cost of $4,992 to the company.

Compressed-Air Receiver

The compressed-air receiver (fig. 6) is made from a steam boiler 6 feet in diameter by 18 feet long with a 3- by 3-foot steam dome.

Air is received from the compressor through an 8-inch pipe line and discharged to the mine through a 5-inch line. The receiver is equipped with a standard safety valve.

Water Supply

Water is obtained from the Gadsden city water supply through a 1-1/2-inch pipe line. A 1-inch line is carried underground to supply drinking water and water for the drills.

Miscellaneous

Three 200-watt electric lamps in weatherproof reflectors are located, one on a pole at the slope portal and two on the head frame for night illumination.

There is a 16-volt surface mine-signaling device with one horn at the mine portal and one in the hoist house.

Power (figs. 6 and 24)

Electric power is purchased from the Alabama Power Co. at rates ranging as follows: Demand charge - $1 per month per kv.-a. of demand plus energy

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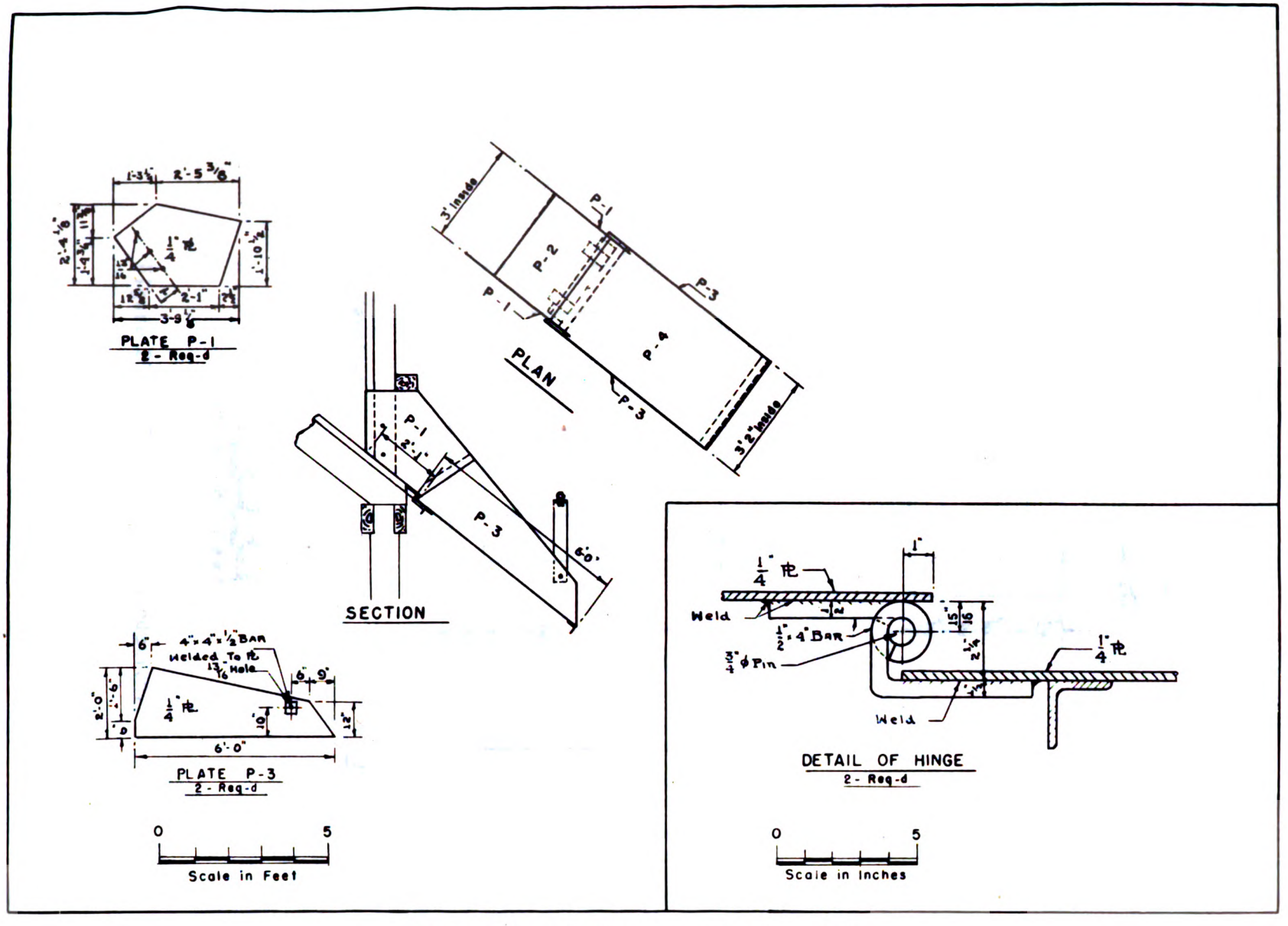

Figure 23. - Railroad car-loading chute.

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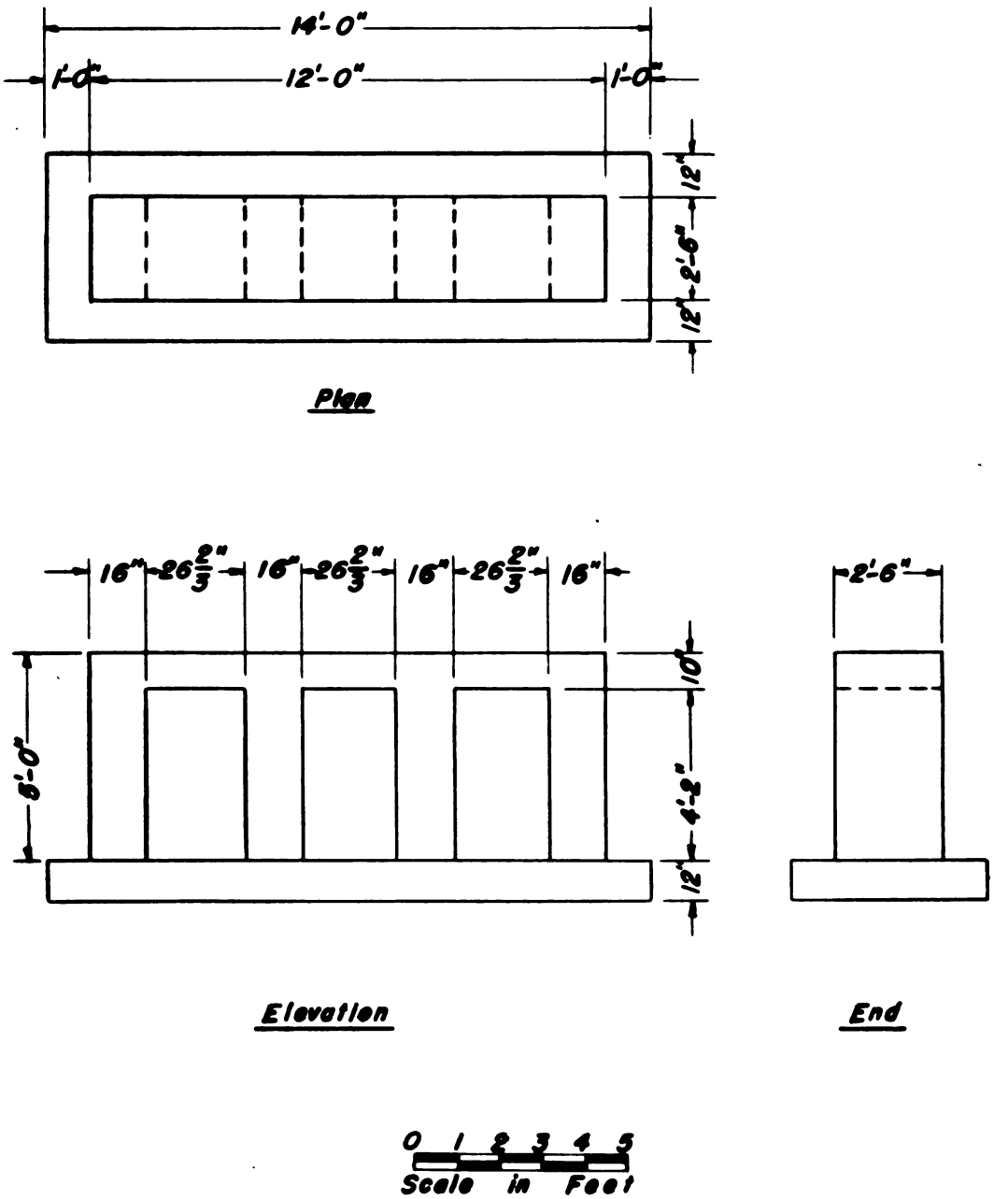

Figure 25. - Transformer foundation.

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charge ranging from 3.0 cents per kw.-hr. for the first 1,000 kw.-hr. consumed per month to 0.4 cent per kw.-hr. for all over 1,000,000 kw.-hr. consumed.

The power company built at its expense about 2 miles of 44,000-volt transmission line to a substation on the mine property (fig. 24).

The mining company installed a bank of three 150 kv.-a. transformers (figs. 24 and 25).

In addition, the mining company built 255 feet of 2,200-volt transmission line and 205 feet of 440-volt line (including 110 feet to mine slope portal) for surface distribution of power.

For underground power there is a 2,200-volt, three-conductor, No. 1 copper-wire rubber-covered submarine cable laid from the transformer bank 110 feet to the mine portal and 420 feet down the slope to the pump station. Three single heavy-rubber-insulated No. 2 copper cables carry the 440-volt current down mine slope. Two rubber-insulated No. 12 copper cables carry the 120-volt lamp current underground.

Costs

The costs of the surface equipment described are tabulated below. Many of these costs are estimates by the author since detailed costs were not available. Figures are rounded to the nearest $10.

Surface plant costs

Item	Total cost
Official residence	$4,700.00
Mine office	4,110.00
Change house	1,700.00
Blacksmith shop	1,440.00
Compressor house and equipment	8,180.00
Hoist house and equipment	11,200.00
Head frame and mine bin:	
(a) Skip incline and dumping ramp	1,050.00
(b) Incline loading frame	120.00
(c) Mine bin	2,320.00
(d) Head frame	630.00
Mine hoist-cable tower	190.00
Feeder and structure	830.00
Picking-conveyor belt and structure	1,320.00
Crusher house and equipment	3,580.00
Conveyor belt to railroad bin	3,890.00
Railroad loading bin	2,170.00
Railroad spur track	4,990.00
Compressed-air receiver and foundation	1,450.00
Water supply	80.00
Miscellaneous light and signals on surface	190.00

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Surface plant costs (Cont'd.)

Item	Total cost
Power:	
(a) Transformer bank	3,220.00
(b) Transmission lines	720.00
	58,080.00
Add 10 percent for miscellaneous and contengencies	5,810.00
	63,890.00
Engineering: Add 5 percent	3,190.00
	67,080.00
Supervision: Add 5 percent	3,350.00
Total cost of surface plant	$70,430.00

MINING EQUIPMENT

The underground mining plant consists of the following, with estimated costs.

Item	Total cost
Rock drills	
(a) 2 - Thor drifters, No. 82, 3-in. cylinder	$ 1,160.00
(b) 2 - Thor single-screw columns, 3 in. x 6 ft., complete with arm, saddle, and safety clamp	240.00
(c) 3 - Thor jackhammers, No. 38, 2-5/8-in. cylinder	735.00
(d) 6 - Thor stopers, No. 275, 2-5/8-in. cylinder	2,730.00
(e) 1 - Thor pavement breaker, No. 25, 2-5/8-in. cylinder	260.00
Pumps	
(a) 1 - Manistee-Roturb, 8- x 6-in. single-stage, centrifugal pump, rated 600 gal. per minute, 220-ft. head. Left in mine in 1919; no purchase cost to company; allow $200 for reconditioning	200.00
(b) 1 - Allis-Chalmers, 8- x 6-in. single-stage, centrifugal pump, rated 1,500 gal. per minute, 220-ft. head; 1,750 r.p.m.	1,300.00
(c) 1 - Gardner-Denver, duplex steam pump, operated with compressed air: 4-1/2-inch steam cylinder, 4-in. stroke, 3-in. water cylinder, maximum rating, 250-lb., water pressure, 48 gal. per minute at 200 strokes per minute	200.00
Motors	
(a) 1 - Westinghouse, 75 hp., 1750 r.p.m., 440 volt, 3-phase, 60 cycle	920.00
(b) 1 - General Electric, 150 hp. 1,750 r.p.m. 2,200 volt, 3-phase, 60 cycle	1,935.00

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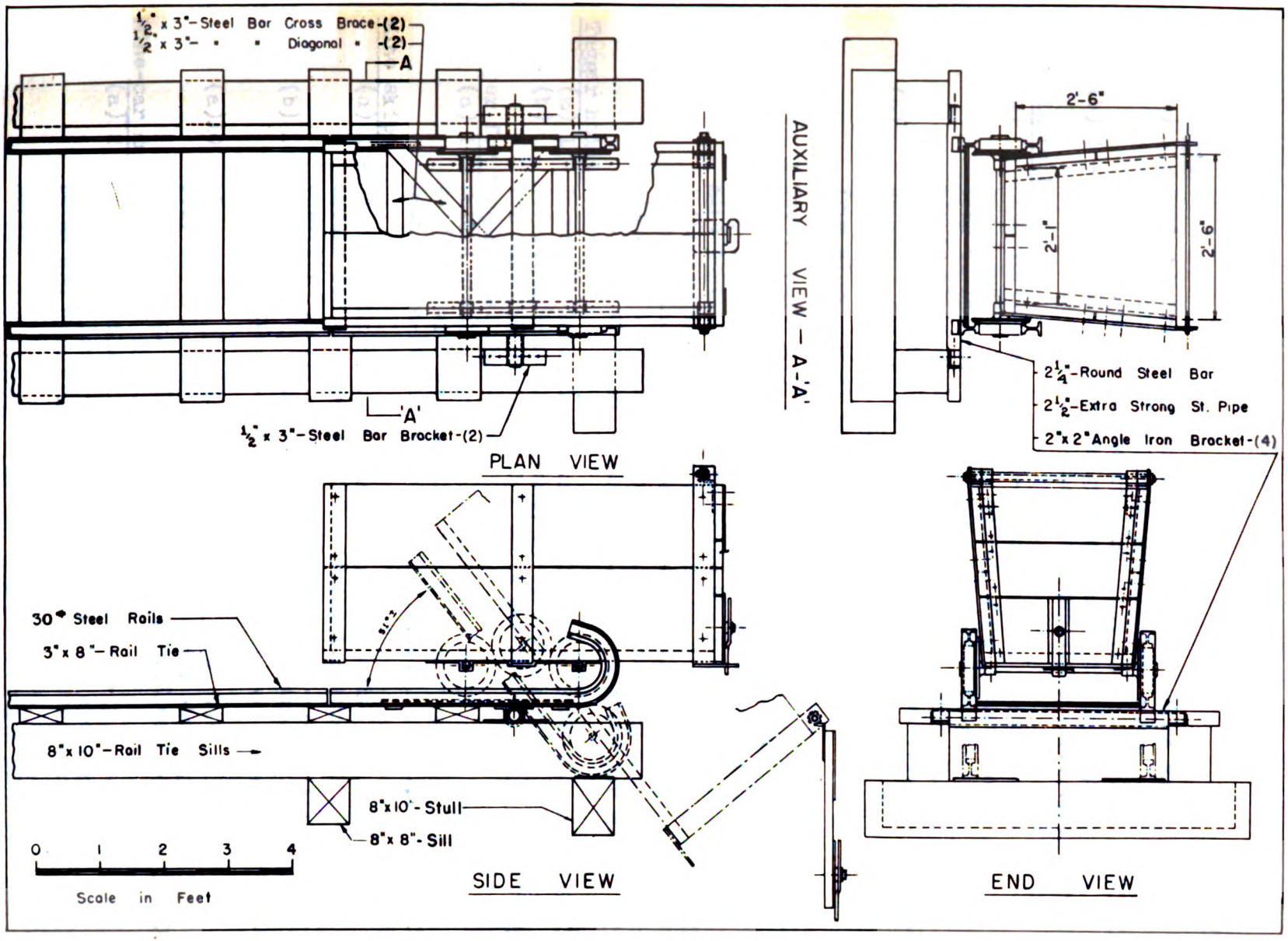

Figure 26. - Mine car and dumping cradle.

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MINING EQUIPMENT (CONT'D.)

Item		Total cost
Motor starters		
(a) 1 -	Bender-Warrick, automatic "start-stop" device and magnetic starter for 75-hp. Westinghouse motor used with Manistee-Roturb pump	$ 800.00
(b) 1 -	General Electric semimagnetic starter for 150-hp. motor used with Allis-Chalmers pump	750.00
Electric cables		
(a)	2200-volt submarine: 3-conductor, No. 1 copper wire, heavy rubber insulation, 535 ft. from transformer bank to 150-hp. motor driving 1,500-gallon-per-minute Allis-Chalmers centrifugal pump, below No. 2 lift, allow 600 feet at $1,250,00 per M feet	750.00
(b)	440-volt cables: 3 single conductors, No. 2 copper wire, heavy rubber insulation, 450 ft. from slope portal to 75-hp. motor driving Manistee-Roturb, centrifugal pump, below No. 2 lift. Allow 1,500 ft. at $292 per M feet	438.00
(c)	120-volt lamp cables: 2 single conductors, No. 12 copper wire, heavy rubber insulation, 450 ft. from mine portal to pump room, below No. 2 lift. Allow 1,000 ft. at $15.00 per M	15.00
(d)	16-volt mine signal wires: 2 single, bare, galvanized No. 4 steel wire; 600 ft. from dumping ramp to bottom of slope. Allow 1,500 ft. at $5.00 per M.	7.50
Tugger hoist		
(a) 1 -	Ingersoll-Rand, double drum hoist, size H-NN-IG	1,026.00
(b)	500 ft. 1/2-inch, 6-strand, 19-wire steel cable for tugger hoist at 15-1/2 cents per ft.	77.50
Scraper for tugger hoist (hoe-type)		
(a) 1 -	Welded steel scraper, 4-1/2 ft. in length, face 2-1/2 ft. wide by 1-1/2 ft. deep; 2' x 2' x 6-inch hard-steel teeth	135.00
Mine skips		
(a) 1 -	Sinking skip, wooden frame with steel axles and wheels for 42-in.-gage slope track; 1.8-ton capacity	130.00
(b) 1 -	6-ton, steel, hoisting skip for 42-in.-gage slope track	660.00
Cars		
(a)10 -	35-cu. ft., 32-inch-gage, end-dump cars, with wooden body and 1-1/2-in. steel axles and 8-in. wheels; built at mine (fig. 26); estimated cost, $75.00 each	750.00
Mine-car dumping cradle (fig. 26)		
(a) 2 -	Dumping cradles: Cradle consists of a 4-ft., 9-in. section of 32-in.-gage track with 30-lb. steel rails, which are upturned 180° on an 8-in. diameter circle and which are welded to 1/2- x 5-in. steel bars. The cradle bearing embodies a 4-ft. 5-in. section of 2-1/2-in. heavy steel pipe which is welded across the bases	

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MINING EQUIPMENT (CONT'D)

Item			Total cost
Mine car dumping cradle (fig. 26) (Cont'd.)		of the rails and through which extends a 2-1/4-in. steel, bearing axle, 4 ft. in length. The axle and ends of cradle are supported on a timber foundation shown in figure 27. Estimated cost built at mine and not including cost of installation, $85.00 each.....	$ 170.00
Mine track			
	(a)	Mine slope: 1,500 ft., 45-lb., steel rails (secondhand) at $50.00 per ton.....	562.50
	(b)	Lift (level) track: 4,000 ft., 30-lb., steel rails (salvaged from old workings).....	-
Pipe			
	(a)	Six-in. water column: 800 ft., "Victaulic", at $110.40 per C ft.....	883.00
	(b)	Five-in. air pipe: 600 ft. "Victaulic" at $85.00 per C ft.	510.00
	(c)	Three-in. pipe: miscellaneous use, 1,000 ft. (secondhand) at $20.00 per C ft.....	200.00
	(d)	Two-in. pipe: 500 ft. (secondhand) at $14.80 per C ft.....	74.00
	(e)	One-and-one-half-in. pipe: 500 ft. at $14.20 per C ft.....	71.00
	(f)	One-in. pipe: 2,000 ft. at $11.90 per C ft.....	238.00
Pipe fittings			
	(a)	Six-in. "Victaulic" couplings: 40 at $4.41.....	176.00
	(b)	Six-in. "Victaulic" Ells: 10 at $7.30.....	73.00
	(c)	Six-in. "Victaulic" Y's: 3 at $24.78	74.00
	(d)	Six-in. "Victaulic" T's: 4 at $15.00	60.00
	(e)	Five-in. "Victaulic" couplings: 30 at $3.40.....	102.00
	(f)	Five-in. "Victaulic" Ells: 10 at $5.60.....	56.00
	(g)	Five-in. "Victaulic" Y's: 2 at $18.50.....	37.00
	(h)	Five-in. "Victaulic" T's: 4 at $3.40.....	14.00
	(i)	Miscellaneous 1-in. to 3-in. fittings, allow.....	250.00
Pipe valves			
	(a)	Six-in., gate valves: 2 at $127.00.....	254.00
	(b)	Five-in., gate valves: 2 at $110.00.....	220.00
	(c)	Three-in., gate valves: 2 at $75.00.....	150.00
	(d)	One-and-one-half-in. globe valves: 4 at $14.00...	56.00
	(e)	One-in., globe valve: 6 at $3.20.....	19.00
	(f)	One-in., air valve: 6 at $5.00	30.00
	(g)	Three-quarter-in. glove valves: 12 at $1.75.....	21.00
	(h)	Miscellaneous pipe and fittings.....	25.00
	(i)	Miscellaneous tools and equipment not listed.....	125.00
Small tools			
	(a) 2 -	Dozen, picks, miners.....	13.00
	(b) 2 -	Dozen, shovels, short-handle, round-point.....	36.00
	(c) 6 -	Bars, 7 ft., 1 in., hexagonal steel	10.50

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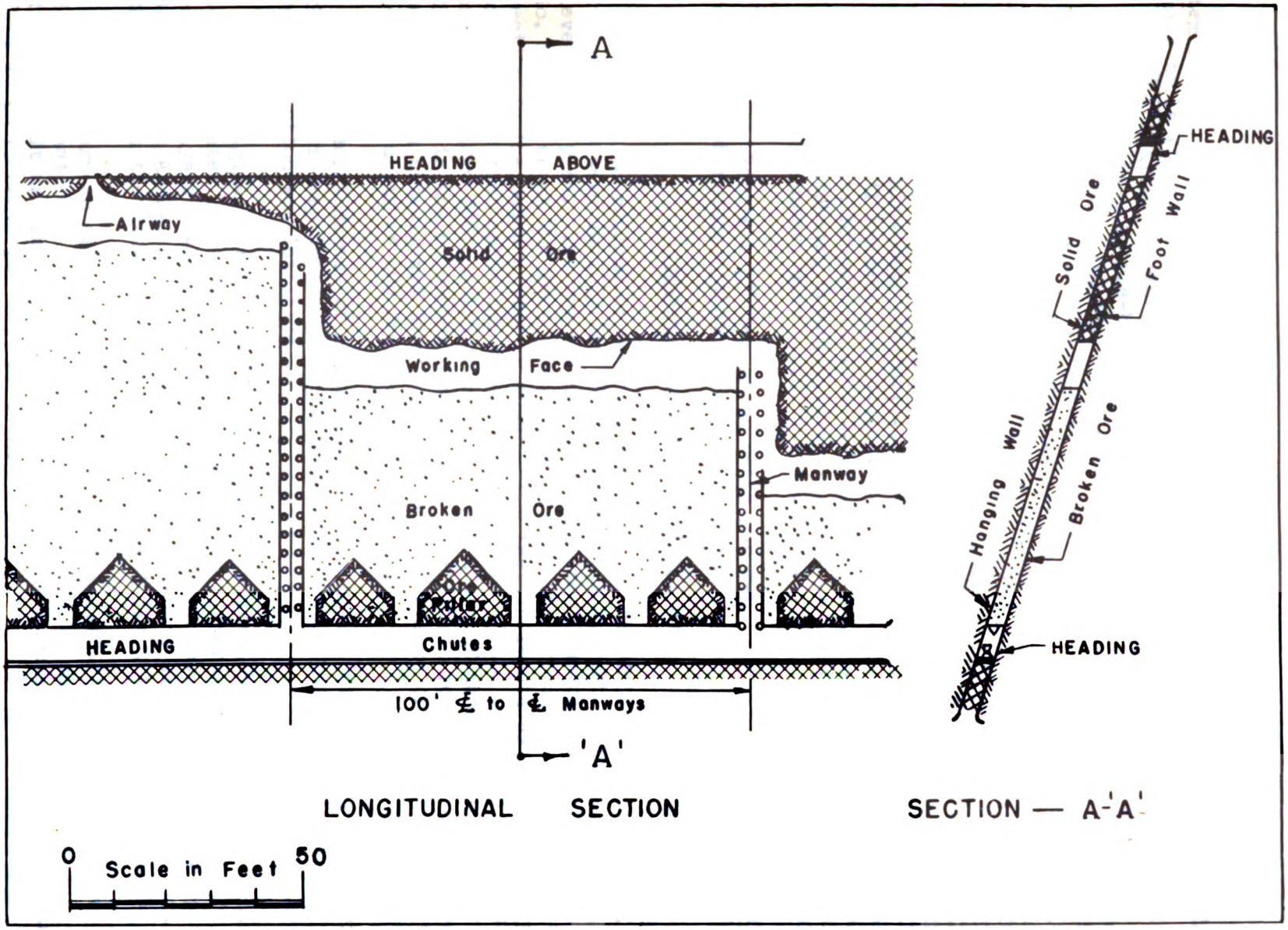

Figure 27. - Sketch of shrinkage-stope development.

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MINING EQUIPMENT (CONT'D)

Item	Total cost
Small tools (Cont'd)	
(d) 6 - Axes, single-blade	$ 13.00
(e) 2 - Axes, double-blade	6.00
(f) 4 - Sledges, 16-lb	8.00
(g) 4 - Sledges, 8-lb	6.00
(h) 2 - Saws, crosscut, 5-ft	10.00
(i) 4 - Saws, hand	12.00
(j) 2 - Saws, hack	5.00
(k) 2 - Wrenches, 12-in., Stillson	5.00
(l) 2 - Wrenches, 16-in., Stillson	6.00
(m) 2 - Wrenches, 36-in., Stillson	24.00
(n) 2 - Chain-tongs, 48-in	32.00
(o) 1 - Rail bender	15.00
(p) 1 - Bit, brace	3.50
(q) 2 - Hatchets, broad	3.50
(r) 2 - Hammers, claw	3.00
Freight	
Estimate 15 tons at 46 cents per cwt.	144.00
Total cost of mining equipment	$ 20,025.50

UNDERGROUND OPERATION (FIG. 4)

Production records of previous operators of the Gadsden and adjoining Etowah mines were used by the company as a basis to justify the present development plan. The ore bed had been exploited from the outcrop to the No. 2 lift, about 200 feet below water level. The extent of the "mined-out" section in the Gadsden mine is about 2,800 feet in length by an average depth of about 400 feet below the outcrop in the plane of the vein (dip 78° to 80°), and about 7,200 feet in length by an average depth of about 600 feet below the outcrop in the adjoining Etowah mine. Therefore, continuity of the ore bed had been established through a horizontal distance of about 10,000 feet in length to a depth of 600 feet below the outcrop.

The Federal Bureau of Mines diamond-drill holes (figs. 3 and 5) comprise the extent of deep drilling on the property but were put down after mine rehabilitation was initiated .

The original estimates of ore, based on production records mentioned, were calculated by using the following factors: Average width - 42 inches; average analysis - 41.48 percent Fe, 10.02 percent CaO, 8.20 percent SiO_2, 4.15 percent Al_2O_3, and 0.44 percent P, which is the average for ore mined and shipped from the Etowah mine; and 11 cubic feet for 1 ton of ore in place.

There are no established market prices for self-fluxing red iron ore. Sales to blast furnaces are based on analyses of ore and requirements of furnaces. It is assumed that the Gadsden ore is purchased at prices ranging from 10 to 13 cents per unit of iron.

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Freight rates for carlots of iron ore, over the Louisville & Nashville Railroad, on August 7, 1947, were: Gadsden to Alabama City - $8.65 a car (switching charge only) regardless of tonnage in car, according to Armstrong;[12] and Gadsden to Birmingham - 64 cents per ton of 2,000 pounds.

Initial work of developing the mine was begun in the spring of 1946. It consisted of building the surface plant, unwatering the mine, and clearing the slope and second lift to establish ventilation through the old workings.

The unwatering job included a section of old workings about 2,800 feet in length by about 200 feet in depth in the Gadsden mine and a section about 7,200 feet in length by about 200 feet in depth in the adjoining Etowah mine.

A 10,000-gallon sump was cut back from the bottom of the slope, about 10 feet vertically below the second lift; and a 10- by 10- by 8-foot pump station cut from the slope into the hanging wall of the ore bed, about 25 feet vertically below the second lift. The flow of mine water gradually decreased to a constant of about 60 gallons per minute, of which about one-half comes from the second lift and the balance from development work below the second lift.

Following clearing of the second lift, for about 1,400 feet to the northeast, two trial stopes were started. This work was abandoned, however, because, owing to the years of submergence, the hanging wall failed to hold as anticipated and the required timbering to prevent dilution would have been too expensive.

Operations were then concentrated on sinking the slope and developing new lifts below the mined-out area.

No detailed operating costs were kept up to this point, and expenditures at this mine were so merged with other operations that they cannot be extracted. Thus the cost of unwatering the Gadsden and Etowah mines and such preparatory work underground done before sinking the slope below the old workings can only be estimated. A tentative estimate made by mine officials is $15,000.

METHOD OF DEVELOPMENT

Plans of development (figs. 4 and 27) are similar to those proved satisfactory in previous operations in the district. They consist of sinking the main slope, 7 by 7 feet, on an incline of 33° in the plane of the ore bed, below the old workings, and driving lifts (levels), 6 by 7 feet, at 100-foot intervals in the plane of the ore bed.

Shrinkage stopes will be started on each lift by raising manways at 100-foot intervals and cutting out for ore chutes at 25-foot intervals. Ten-foot pillars extending 7-1/2 feet up the dip will be left between ore chutes. Simple stop-board ore chutes, built on the footwall side of the ore bed, were used by previous operators. The present management proposes to install simple

12/ See footnote 10.

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longitudinal, two timber set, stop board, ore chutes with openings to discharge ore into cars directly over the center of the track.

Stulled manways, 4 by 5 feet, lagged off from broken ore, are carried up as stoping progresses. These manways will also be used as supply raises to stope faces.

It is proposed to stope the entire length of the ore bed, within the limits of the property, where the grade and width of ore will permit profitable mining, without the use of pillars between stopes. This practice was followed by previous operators in the Gadsden and adjoining Etowah mines.

An ore pocket will be raised from the back of the slope (inclined shaft) through to each developed lift, beginning at a point about 40 to 50 feet below the lift on the dip of the bed. A simple stop-board chute will be constructed with timber for loading the mine skip. The dimensions of the opening at the slope will be about 5 by 5 feet and increase to about 5 by 20 feet, 10 feet above the back of the slope and continue to the lift above. Each pocket will provide for storage of about 250 tons of broken ore. Mine-car dumping cradles (fig. 26) will be installed at ore pockets on each level.

The dimensions of the main slope down to the second lift vary from 4 to 7 feet in height and from 7 to 10 feet in width. The dimensions of old drifts vary from 4-1/2 to 8 feet in height and from 4-1/2 to 7 feet in width. Under the recent development plan the slope was sunk 206 feet below the No. 2 lift with dimensions of 7 by 7 feet and the third lift was driven 59 feet with dimensions of 6 by 7 feet in the clear.

No timber is required in the main slope except for 30 feet from the portal. The ore and wall rocks are remarkably consistent in firmness and show no signs of breaking or checking along the old slope above the second lift, which was under water from 1919 to 1946.

Development cost details cover 206 feet of the slope below the second lift and 59 feet of level along the third lift, from May 19 to July 11, 1947.

Development work is carried out by contract. The contractor is paid $70 for each linear yard of 7- by 7-foot slope and $65 for each linear yard of 6- by 7-foot level. The contractor hires his own men and furnishes all supplies incident to drilling, including detachable rock-drill bits, blasting, and delivering broken rock to the mine bin. The contractor also lays tracks and pipe lines up to working faces and operates the sinking pump. The company furnishes electricity, fresh water, compressed air and mining and drilling equipment and pays for hoistmen, mechanics, and surface laborers.

The contractor's normal crew comprised one driller, one helper, four muckers, and three chainmen (skiptenders). The company's crew consisted of three hoistmen and two surface laborers; the hoistmen also operate the compressor; and the day-shift hoistman also attends to mechanical assignments when hoisting is inactive.

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Drilling equipment used embraced a Thor No. 82 drifter, a 3-inch by 6-foot single screw column, complete with arm, saddle, and safety clamp; 2-, 4-, 6-, and 8-foot lengths of hollow, 1-inch, hexagonal, drill steel, threaded for Timkin, detachable, cross drill bits; drill bits (sizes 2, 1-7/8, 1-3/4, and 1-5/8 inches); a 50-foot length of 1/2-inch rubber water hose; a 50-foot length of 1-inch rubber air hose; drill wrenches, pipe wrenches, and wooden blocks for the drill column.

A typical round for the slope is shown in figure 28. It consists of a 14-hole V-cut round, with 7- to 8-foot cut holes and 6- to 7-foot reliever, back, and lifter holes. The normal round is drilled, loaded, and blasted within an 8-hour shift.

Fifty pounds of 1-1/4- by 8-inch du Pont or Hercules 40-percent gelatin was used to each round. No. 6 electric blasting caps, consisting of direct and four delays were used to detonate the round.

A typical drift round is shown in figure 29. It consists of a 14-hole V-cut round with same hole arrangement shown in figure 28. The round embraces 6- to 7-foot cut holes and 6 to 6-1/2-foot relievers, back and lifter holes. The normal round is also drilled and blasted within an 8-hour shift.

Fifty pounds of du Pont or Hercules 40-percent gelatin is used to each round. The round is detonated with No. 6 electric blasting caps, consisting of direct and four delays.

The cycle of operation normally started with drilling and blasting on the day shift, 7 a.m. to 3 p.m. The afternoon shift, 3 p.m. to 11 p.m., and night shift, 11 p.m. to 7 a.m., were used to muck out the round and clean up the face and to extend track and pipe lines.

The slope was sunk to the third lift, where 59 feet of drift was driven from the back of the slope to cut the third lift station. Then the slope was continued below the third lift.

The ore bed and wall rocks are firm, and no timber will be required to protect mine working. The developed flow of mine water below the second lift, down to the third lift amounted to about 30 gallons per minute. The flow of water on the second lift increases during heavy storms; at times it is necessary to use the Allis-Chalmers 1,500-gallon-per-minute emergency pump.

Since development faces include the ore bed, about 3-1/2 feet in thickness and 2-1/2 to 4 feet of waste rock, the broken round is a waste product. This is hoisted to the mine bin in the wood-frame skip, about 1.8 tons per load, and dumped into the waste compartment.

Waste rock is hauled from the mine bin to dumps by a truck contractor. Large pieces of ore are hand-sorted into piles, which are picked up from time to time and shipped to the blast furnaces.

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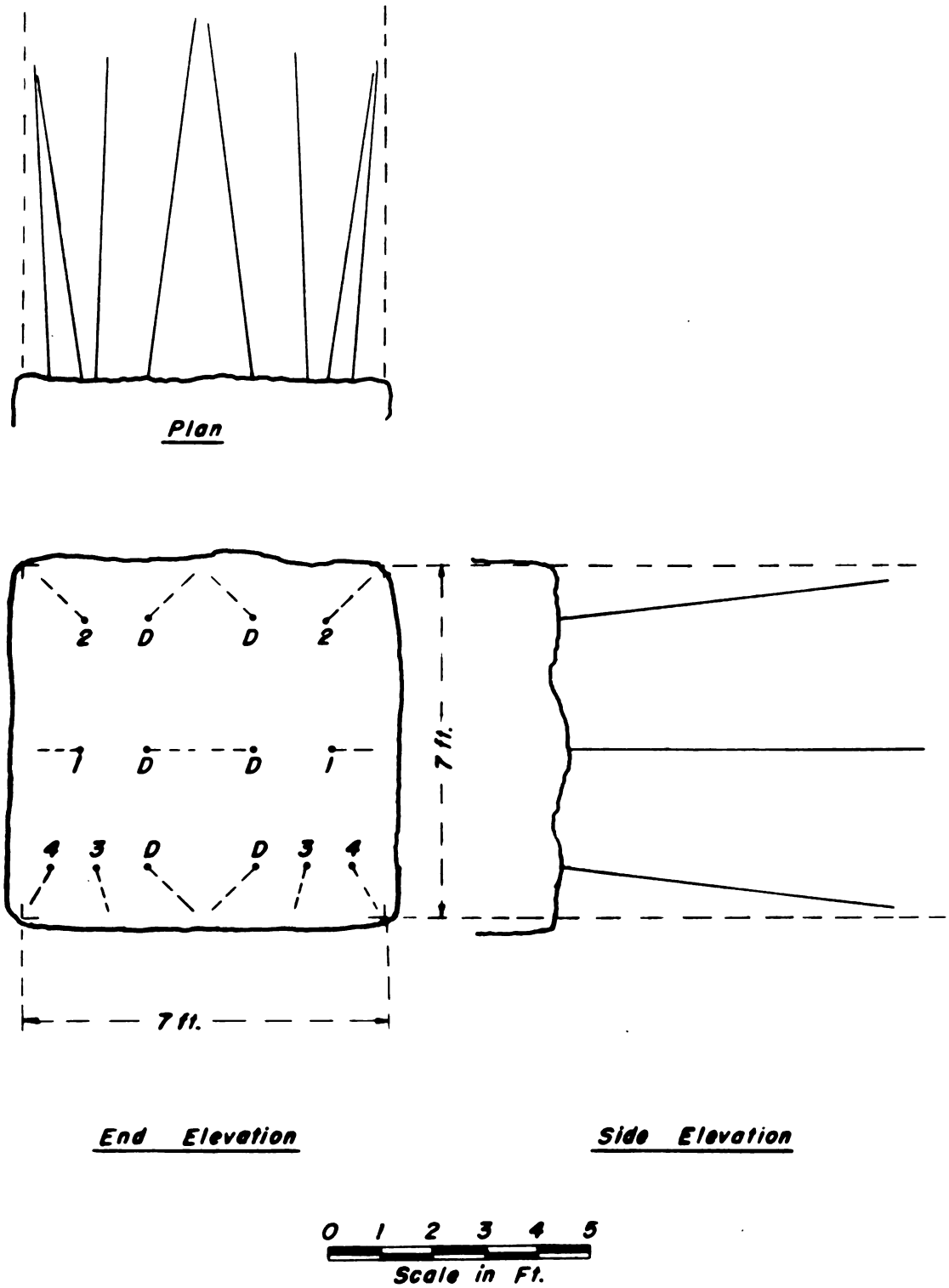

Figure 28. - Typical slope round.

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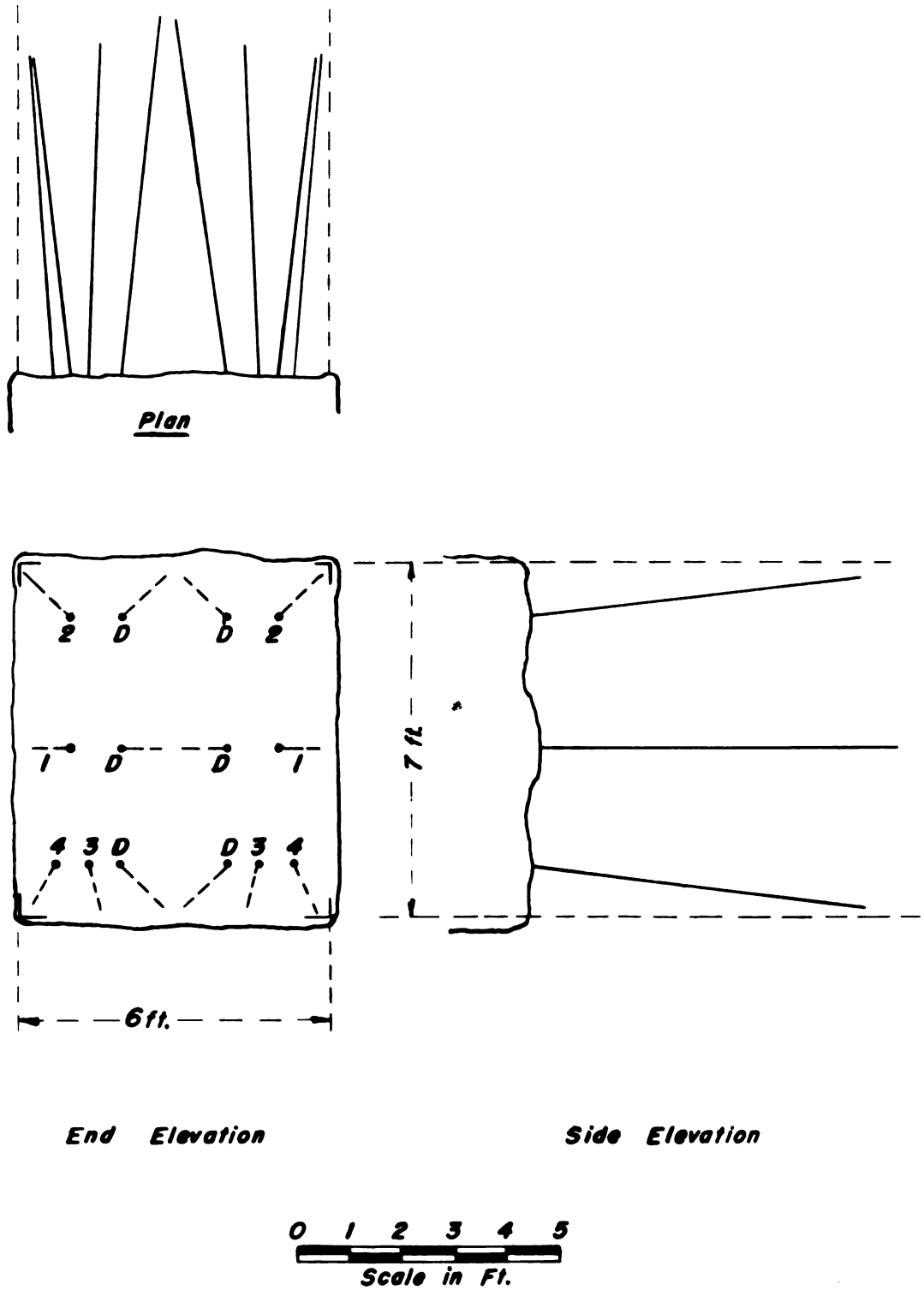

Figure 29. - Typical drift round.

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DEVELOPMENT COSTS

May 19 to July 11, 1947

Two hundred six feet of 7- by 7-foot 33° slope sunk in medium-hard rock without timber required 41 8-hour shifts drilling and blasting; 82 8-hour shifts mucking and hoisting; and 42 24-hour days pumping.

Fifty-nine feet of 6- by 7-foot level in medium-hard rock without timber required 12 8-hour shifts drilling and blasting; 24 8-hour shifts mucking and hoisting; and 12 24-hour days pumping. The cost a foot in man-hours and power units follows:

Labor	Man-hr. Sinking per ft.	Man-hr. Drifting per ft.
Drilling and blasting	6.36	6.54
Shoveling	6.35	6.54
Haulage and handling	9.75	9.76
Supervision	1.59	1.55
Total labor	24.05 man-hr.	24.39 man-hr.

Power and supplies	Sinking per ft.	Drifting per ft.
Explosive	9.94 lb.	10.02
Number of elect. caps	2.8	2.7
Rock bits	1.8	1.9
45-lb. rails	2.0 ft.	-
30-lb. rails	-	2.0 ft.

Total power	KW.-hr. Sinking per ft.	KW.-hr. Drifting per ft.
Compressor		
Drilling and blasting	39.7	40.6
Blowing out round (smoke and gas)	9.9	10.2
Ventilation	30.3	30.5
Pumping (sinker)	13.2	13.4
Pumping (booster)	5.2	5.3
Hoisting	7.2	5.6
Pumping (direct)	91.4	89.4
Miscellaneous		
Lighting, welding, and crusher and conveyors	9.9	10.2
Total KW.-hr.	206.8	205.2

Miscellaneous (general)		
Hauling waste from mine bin at 10 cents per ton	45 cents	38 cents

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Cost of supplies at plant

Explosives:

40-percent gelatin, du Pont, 1-1/4 by 8-in., 50-lb. box, $10.25

Electric detonating caps:

Direct	$ 9.50 per C
1st delays	15.50 per C
2d delays	16.00 per C
3d delays	17.50 per C
4th delays	18.00 per C

Drill steel

1 - inch hollow hexagonal, prepared lengths for Timkin bits

Cost per length	2 ft.	4 ft.	6 ft.	8 ft.
Drifter	$4.25	$4.45	$5.75	$7.00
Jackhammer	3.05	4.25	5.50	6.75
Stoper	2.80	4.07	5.28	6.25

Drill bits (Timkin detachable cross bits)

Sizes:	2 in.	1-7/8 in.	1-3/4 in.	1-5/8 in.
Cost per C.	$37.30	$37.00	$36.00	$35.50

Lumber and timber

Sawmill rough, $50 to $60 per M bd. ft.

Posts, 6 to 8 in. round by 8 ft., 20 cents per ft.

Posts, 8 to 12 in. round, by 8 ft., 30 cents per ft.

Rails

45-lb., secondhand, $590 per ton

30-lb., none purchased; all used to date were recovered from old workings.

Pipe

Victaulic (actual price)

6-inch pipe, 21-ft. lengths	$110.40 per 100 ft.
6-inch "Ell's"	7.30 each
6-inch "Y's"	24.78 each
6-inch couplings	4.41 each

Victaulic (estimated price)

5-inch pipe, 21-ft. lengths	85.00 per 100 ft.
5-inch "Ell's"	5.60 each
5-inch "Y's"	18.50 each
5-inch couplings	3.40 each

Standard pipe

3-inch with sleeves (secondhand)	20.00 per 100 ft.
2-inch with sleeves	23.00 per 100 ft.
1-1/2-inch with sleeves	14.20 per 100 ft.
1-inch with sleeves	11.90 per 100 ft.
3/4-inch with sleeves	4.95 per 100 ft.

The wage scale as adopted is as follows:

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	Hourly rate
Miners	None
Mechanics	$1.26
Hoistmen	1.19
Timbermen	1.00
Trammers	1.00
Muckers	.86
Laborer (common, surface)	.85

No wage scale was established for miners because none were available in the district. The contractor's wage rates were not available.

SUPPLEMENTAL DEVELOPMENT COSTS

July 12 to September 3, 1947

On July 12 the contractor built a timber platform in the slope at the third lift station and installed a double-drum tugger hoist and scraper to clear broken rock from the level drift and dump it directly into slope skip, through a 2- by 2-foot hole in the platform. The 1.8-ton timber skip was replaced with a 6-ton steel skip.

The contractor's crew was increased from 9 to 15 men, comprising: 2 machine drillers, 2 drill helpers, 3 chainmen (skip tenders), 6 muckers, and 2 laborers.

During the period from July 12 to September 3, 1947, the following development work was completed, by contract, in medium-hard rock, except as noted below, without the use of timber:

95 ft. of 7- by 7-ft., 33° slope; at $70.00 a linear yard.

146 ft. of 6- by 7-ft. drift, on 3d lift northeast of slope; at $65.00 a linear yard.

54 ft. of 6- by 7-ft. drift on 3d lift, southwest, around southeast side of slope, in very hard rock, at $65.00 a linear yard.

102 ft.; increased width of drift from 6 to 8 ft. to provide for double track along 3d lift, northeast of slope; at $20.00 a linear yard.

23 ft. of 5- by 5-ft. raise; at $65.00 a linear yard.

The costs a foot in man-hours and power units follow:

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July 12 to September 3, 1947

Labor	Man-hr. Sinking per ft.	Man-hr. Drifting per ft.	Man-hr. Raising per ft.	Man-hr. Drift slabbing per ft.
Drilling and blasting	6.40	7.52	6.96	1.57
Shoveling	5.05	1.72	3.48	2.35
Mucking and scraping	-	3.68	-	-
Haulage and handling	15.92	10.88	10.78	2.51
Supervision	2.27	2.68	2.43	0.55
Total Labor	29.64	26.48	23.65	6.98

Supplies	Sinking per ft.	Drifting per ft.	Raising per ft.	Drift Slabbing per ft.
Explosives	10.00 lb.	10.00 lb.	10.87 lb.	1.5 lb.
Electric caps	2.7	2.7	3.4	.6
Rock bits	2.0	4.0	2.2	.5
45-lb. steel rails	2.0 ft.	-	-	-
30-lb. steel rails	-	2.0 ft.	-	-

Electric power	KW.-hr. Sinking per ft.	KW.-hr. Drifting per ft.	KW.-hr. Raising per ft.	KW.-hr. Drift slabbing per ft.
Compressor				
Drilling and blasting	40.0	47.0	43.5	11.3
Blowing out smoke & gas	10.0	10.0	10.9	2.5
Ventilation	20.0	23.5	21.7	8.8
Pumping (sinker)	11.3	10.3	9.6	3.2
Pumping (booster)	4.5	4.1	3.8	1.3
Hoisting	7.1	6.1	3.7	2.0
Pumping (direct)	75.6	68.9	63.8	21.6
Miscellaneous				
Lighting, welding, tugger-hoist crusher, conveyors, etc.	8.6	15.1	7.3	2.4
Total kw. hr.	177.1	185.0	164.3	53.1

Miscellaneous (general)	Cost per ft. Sinking	Cost per ft. Drifting	Cost per ft. Raising	Cost per ft. Drift slabbing
Hauling waste from mine bin at 10 cents per ton	45 cents	38 cents	23 cents	13 cents

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